

~~XIV~~ ~~6~~ ~~37~~
~~HH~~ ~~6~~ ~~12~~
A

S Y S T E M
OF
A N A T O M Y
AND
P H Y S I O L O G Y;

FROM THE
LATEST and BEST AUTHORS.

ARRANGED,
AS NEARLY AS THE NATURE OF THE WORK WOULD ADMIT,
IN THE
Order of the LECTURES delivered by the PROFESSOR of
ANATOMY in the UNIVERSITY of EDINBURGH.

THE SECOND EDITION.
IN THREE VOLUMES.

TO WHICH IS ADDED,
THE COMPARATIVE ANATOMY.

ILLUSTRATED WITH COPPERPLATES.

V O L. II

EDINBURGH:
PRINTED FOR CHARLES ELLIOT, EDINBURGH;
C. ELLIOT and CO. opposite SOMERSET-HOUSE
in the STRAND; and G. G. J. & J. ROBINSON,
PATERNOSTER-ROW, LONDON.

M,DCC,LXXXVII.



C O N T E N T S

OF THE SECOND VOLUME.

P A R T VI.

Description of the Viscera and Organs.

CHAP I. <i>Of the Head,</i>	9
<i>Pericranium,</i>	ib.
Se&t. I. <i>Of the Brain and its Appendages,</i>	10
§ 1. <i>Dura Mater,</i>	11
§ 2. <i>Pia Mater,</i>	21
§ 3. <i>Cerebrum,</i>	23
§ 4. <i>Cerebellum,</i>	33
§ 5. <i>Medulla Oblongata,</i>	35
§ 6. <i>Medulla Spinalis,</i>	40
§ 7. <i>The Nerves of the Brain and Spinal Mar- row, from their origin to their going out of the Cerebrum and Spine,</i>	43
§ 8. <i>Blood-vessels of the Brain and Medulla Spinalis,</i>	51
<i>Quantity of Blood determined to the Head,</i>	55
<i>Its Lymphatic Vessels,</i>	60
<i>Seat of the Soul discussed,</i>	67
Se&t. II. <i>The Eye.</i>	75
§ 1. <i>The Eye in general,</i>	ib.
§ 2. <i>The Globe or Ball of the Eye,</i>	77
§ 3. <i>The Coats of the Eye in particular,</i>	78
A 2	§ 4. <i>The</i>

§ 4. <i>The Humours of the Eye, and their Capsula,</i>	83
§ 5. <i>The Tunica Albuginea and Muscles of the Globe of the Eye,</i>	86
§ 6. <i>The Supercilia, and Musculi Frontales, Occipitales, and Superciliares,</i>	89
§ 7. <i>The Palpebræ and Membrana Conjunctiva,</i>	91
§ 8. <i>The Muscles of the Palpebræ,</i>	97
§ 9. <i>The Vessels of the Eye and its Appendages,</i>	98
§ 10. <i>The Nerves of the Eye and its Appendages,</i>	99
§ 11. <i>Sight,</i>	102
<i>Light, action of it on the Eyes,</i>	106
<i>Different Affections of Sight,</i>	113
SECT. III. <i>The Nose,</i>	118
<i>Its Physiology,</i>	127
§ 1. <i>Of Smelling,</i>	ib.
SECT. IV. <i>The Ear,</i>	130
<i>Its Physiology,</i>	152
<i>Hearing,</i>	ib.
SECT. V. <i>The Mouth,</i>	159
§ 1. <i>The Cheeks, Lips, and Gums,</i>	160
§ 2. <i>The Palate, Uvula, &c.</i>	163
§ 3. <i>The Tongue,</i>	165
<i>Taste,</i>	171
§ 4. <i>The Larynx,</i>	174
<i>Voice and Speech,</i>	182
§ 5. <i>The Pharynx,</i>	187
§ 6. <i>The Salival Glands, &c.</i>	189
§ 7. <i>Mastication, Saliva, and Deglutition,</i>	193
CHAP. II. <i>Of the Thorax,</i>	202
§ 1. <i>Mammæ,</i>	204
§ 2. <i>Pleura and Mediastinum,</i>	208
§ 3. <i>Thymus,</i>	211
§ 4. <i>Pericardium,</i>	212
§ 5. <i>Of</i>	

§ 5. <i>Of the Heart,</i>	114
<i>Heart's Physiology, Motion, and Use,</i>	226
§ 6. <i>Of the Nature of the Blood and Juices of the Human Body,</i>	244
<i>Temperaments,</i>	254
§ 7. <i>Circulation of the Blood,</i>	260
§ 8. <i>Lungs,</i>	267
§ 9. <i>Respiration,</i>	279
<i>Its Effects on the Blood,</i>	297
§ 10. <i>Oesophagus,</i>	303
§ 11. <i>Ductus Thoracicus,</i>	305
 CHAP. III. <i>Of the Abdomen,</i>	306
§ 1. <i>Peritonæum,</i>	308
§ 2. <i>Ventriculus,</i>	313
§ 3. <i>The Intestines in general,</i>	321
§ 4. <i>The Duodenum in particular,</i>	324
§ 5. <i>Intestinum Jejunum,</i>	327
§ 6. <i>Intestinum Ileum,</i>	329
§ 7. <i>The Intestina Crassa in general,</i>	330
<i>The Intestinum Cæcum in particular,</i>	331
§ 8. <i>The Intestinum Colon,</i>	332
§ 9. <i>Intestinum Rectum and Anus,</i>	336
§ 10. <i>Mesenterium and Mesocolon,</i>	338
§ 11. <i>The Blood-vessels and Nerves of the In- testines,</i>	342
§ 12. <i>Digestion,</i>	346
§ 13. <i>Hepar and Vesicula Fellis,</i>	365
§ 14. <i>Pancreas,</i>	380
§ 15. <i>Lien,</i>	383
<i>Physiology of the Spleen,</i>	387
§ 16. <i>Omentum and Appendices Epiploicæ</i>	390
§ 17. <i>Secretion of the Bile,</i>	394
§ 18. <i>Rens et Ureteres,</i>	407
§ 19. <i>Glandulæ Renales, vulgo Capsulæ Atra- biliaria,</i>	414

CHAP. IV. <i>Of the Pelvis,</i>	419
§ 1. <i>Vesica Urinaria,</i>	ib.
§ 2. <i>Secretion of Urine,</i>	423
§ 3. <i>The Parts of Generation in Males,</i>	427
§ 4. <i>Secretion of the Semen,</i>	450
§ 5. <i>The Parts of Generation in Females,</i>	458
<i>Explanation of Tab. IX. and X. from Cheselden,</i>	472

419
ib.
423
427
450
458
472

A
S Y S T E M
O F
A N A T O M Y,
WITH THE
P H Y S I O L O G Y.

P A R T VI.

Containing a DESCRIPTION of the

D I F F E R E N T V I S C E R A.

E M
C H A P I.

Of the HEAD.

BESIDES the brain, which is contained within the cranium, the head presents to us the organs of sight, of sound, of smell, of taste, and the greater part of those which serve for deglutition.

THE PERICRANIUM.

BESIDES the external integuments of the head, viz. the hair, skin, and cellular substance, there are two o-
Vol. II. B ther

ther expansions on the head; the first is the tendon of the occipito-frontalis muscle; the second is the pericranium, which covers the external surface of all the bones of the cranium.

The external part of this membrane may be said to separate from the other at the semicircular plane upon the side of the cranium, mentioned in the description of the bones; and becomes a very strong aponeurosis, which covers the temporal muscle, and is afterwards fixed to the external process of the os frontis, and to the upper edge of all the zygoma. The rest of the pericranium is connected to the other parts of the head.

The head, being considered in general as one of the three principal cavities of the human body, has this peculiar to it, that its outside is the seat and basis of several very complex particular organs; whereas on the inside it contains only one, which is indeed the primum mobile of the whole animal œconomy; namely, the brain; the mechanism of which is very little known; and the structure of its different parts, even of those which we are supposed to be most acquainted with, is very difficult to be demonstrated.

SECT. I. *Of the BRAIN and its APPENDAGES.*

THE name of *brain* is given to all that mass which fills the cavity of the cranium, and which is immediately surrounded by two membranes, called *meninges* by the Greeks, and *matres* by other ancients, because they were commonly of opinion that these membranes were the origin, and, as it were, the mother, of all the other membranes of the body.

This general mass is divided into three particular portions; the cerebrum or *brain* properly so called, the cerebellum, and medulla oblongata. To these three parts contained within the cranium, a fourth is added, which

which fills the great canal of the spina dorsi, by the name of *medulla spinalis*, being a continuation of the medulla oblongata.

The meninges, or membranes, are two in number; one of which is very strong, and lies contiguous to the cranium; the other is very thin, and immediately touches the brain. The first is named *dura mater*; the second *pia mater*. This last is again divided into two; the external lamina being termed *arachnoides*, the internal retaining the common name of *pia mater*. We begin with these meninges.

§ 1. *Dura Mater.*

Situation in general. The dura mater incloses the brain and all its appendages. It lines the inside of the cranium, and supplies the place of an internal periosteum, being spread in holes and depressions, and covering all the eminences in such a manner as to prevent their being hurtful to the brain.

Division. In describing the dura mater, we must take notice, 1. Of its composition. 2. Its adhesions to the cranium. 3. Its folds or septa. 4. Its productions, vessels, and nerves.

Composition. The dura mater is composed of one lamina; although it may, by maceration, be divided into two or more. Its texture is very close and strong, appearing to be partly ligamentous and partly tendinous.

Adhesion. The dura mater sticks closely to the cranium by a great number of filaments of the external surface, which enter the pores of the bones, almost every where, but more particularly at the sutures both above and below; and by penetrating these joints, they communicate with the external periosteum. These filaments are, for the most part, small vessels; which being broken in separating the dura mater from the skull,

a great number of red points appear on the external surface of that membrane.

It adheres much more to the whole inner surface of the cranium in children and young persons than in those of an advanced age; the filaments become then very small, being compressed by the contraction of the bony pores; and consequently they are more easily ruptured by any force applied to them.

These adhesions are formed entirely by the outer surface of this membrane, the inner part of it being very smooth and polished, and is also continually moistened by a fine fluid discharged thro' its pores, much in the same manner as the peritonæum and pleura.

Folds and septa. The dura mater sends off several processes; three of which form particular septa that divide the brain into certain parts. One of them is superior, representing a kind of mediastinum between the two great lobes of the brain: The second is in a middle situation like a diaphragm, between the cerebrum and cerebellum: the third is inferior, between the lobes of the cerebellum. The superior septum is longitudinal in form of a scythe, from whence it is termed the *falx of the dura mater*; and it may likewise be called *septum sagittale, verticale, or mediastinum cerebri*. The middle septum is transverse; and might be called *the floor of the cerebrum, the diaphragm of the brain, tentorium cerebelli*. The inferior septum is very small, and runs down between the lobes of the cerebellum; on which account it may be termed either simply *septum cerebelli*, or *septum occipitale minus*, the middle partition being looked upon as the *septum occipitale majus*.

The superior or vertical septum, called the *falx of the dura mater*, is a long and broad fold or duplicature of the internal part, reaching from the edge of the crista Ossis Cribrosi, along the sagittal future, to the middle of the transverse septum; which it joins in such a manner, as that the lateral laminæ of the falx are continuous

tinuous on each side with the neighbouring portions of the superior lamina of the middle septum.

It is broader where it joins the middle septum than at the os ethmoides; and it is thicker at that edge which adheres to the cranium than at the other, which lies loose and is very sharp; and from this resemblance to a scythe, it had the name of *falx*.

The transverse or middle septum, called *tentorium cerebelli*, is fixed to the os occipitis along the grooves of the lateral sinuses, and those of the great angles of the apophyses petrosæ all the way to the posterior clinoid apophyses of the os sphenoidale. By this situation it forms a sort of floor, tent, or shallow vault, on the fore-part of which is a large notch almost of an oval figure.

This septum divides the cranium into two cavities, one larger or superior, and the other small or inferior, which communicate together by the great oval notch. It is formed by a particular fold, and a very broad membrane of the internal part of the dura mater; and in the natural state it is very tense, because of its union or rather continuity with the falx.

This union or continuity of these two septa keeps them both very tense, so that the middle septum is capable of sustaining a considerable weight without sinking downward; and the falx is able to resist lateral pressures, without giving way to the right or left side.

We may be convinced of this reciprocal tension, by first touching these two septa in their natural state; and again, after they have been cut one after the other according to their breadth; or rather after having cut in this manner the falx in one subject, and the transverse septum in another: for as soon as the falx is cut, the other will be perceived immediately to lose its tension and firmness; and the same thing will be observed in the falx as we cut the tentorium.

The small occipital septum is both very short and narrow. It runs down from the middle of the transverse

septum to the edge of the great occipital hole, being fixed to the internal spine of the os occipitis. It is formed by a fold and duplicature of the internal part of the dura mater, in the same manner as the other two, and distinguishes the lower part of the occipital cavity of the cranium into two lateral parts. In some subjects this septum is double, answering to the double spine of the os occipitis.

Sphenoidal folds. Besides these large folds, there are two small lateral ones on each side of the sella turcica, each running from the posterior to the anterior clinoid apophysis on the same side. These two folds, together with the anterior or posterior parts of the sella turcica, form a small fossula, in which the pituitary gland is lodged. There are likewise two anterior folds at the edges of the sphenoidal or superior orbital fissures, which augment the depth of the middle fossulæ of the basis cranii. Thus we have seven folds of this membrane, three large and four small, which may be termed *internal productions or processes of the dura mater.*

Elongations. The elongations of the dura mater go beyond the general circumference, and pass out of the cranium, through the openings described in the treatise of the skeleton, and may be named *external productions of the dura mater.*

The most considerable of these elongations passes through the great occipital foramen, and runs down the common canal of the vertebræ in form of a tube, lining the inside of that canal, and inclosing the medulla spinalis, by the name of the *dura mater* of that medulla. The other elongations accompany the nerves out of the cranium in form of vaginæ, which are more numerous than the nervous trunks reckoned in pairs. For the olfactory nerves, there is the same number of distinct vaginæ as there are holes in the lamina ethmoidalis; and some nerves are accompanied by several vaginæ through one hole, as those of the ninth pair.

There

There are two particular elongations which form the periosteum of the orbits, together with the vaginæ of the optic nerves. These orbital elongations go out by the superior orbital fissures, or foramina lacera of the sphenoid bone; and, increasing in breadth in their passage, line the whole cavity of the orbits, at the edges of which they communicate with the pericranium and periosteum of the face. They communicate likewise, through the spheno-maxillary or inferior orbital fissures, with the pericranium of the temporal and zygomatic fossæ; and by these communications we may explain the accidents which happen to these parts in wounds of the head.

The elongations of the dura mater which accompany the blood-vessels through the foramina of the cranium, unite with the pericranium immediately afterwards. Such, for instance, are the elongations which line the fossulæ of the foramina lacera or jugularia, and the bony or carotid canals of the apophysis petrosa, &c.

Arteries. The vessels of the dura mater are arteries, veins, and sinuses. The arteries in general are distinguished into anterior, middle, and posterior; and come from the carotids and vertebrales on each side. The external carotid sends a branch through the spinal hole of the os sphenoidale, which is the middle artery of the dura mater; and is called, by way of eminence, *arteria duræ matris*. It is divided into a great number of branches, which are plentifully dispersed through the substance of the external lamina as high as the falx, where these ramifications communicate with their fellows from the other side. The impressions of this artery are seen on the inside of the parietal bones; the anterior and lower angle of which, instead of a simple impression, contains a canal for the passage of a trunk or branch of this artery; on which account several accidents happen in fractures of the skull.

The external carotid sends another small ramus
B 4 through

through the corner or small end of the sphenoidal or superior orbital fissure; where there is sometimes a little notch on purpose, mentioned in the Description of the Skeleton. This branch is the anterior artery of the dura mater; and it gives off ramifications in the same manner as the former with which it communicates, but its ramifications are not so numerous. The internal carotid, as it enters the cranium, gives off a small branch to the substance of the dura mater.

The two vertebral arteries enter by the great occipital foramen, and unite in one trunk on the anterior or sphenoidal apophysis of the os occipitis. Immediately after they pass through the dura mater on both sides, each of them sends one or two branches to that membrane. These are the posterior arteries of the dura mater; and they communicate by some ramifications with the middle or spinal artery above mentioned.

Veins and sinuses. The dura mater contains in its duplicature several particular canals; into which the venous blood, not only of that membrane, but of the whole brain, is carried. These canals are termed *sinuses*; and some of them are disposed in pairs, others in uneven numbers: that is, some of them are placed alone in a middle situation; others are disposed laterally on each side of the brain. The most ancient anatomists reckoned only four; to which we can now add several others.

These sinuses are in the duplicature of the dura mater; and their cavities are lined on the inside by particular very fine membranes. They may be enumerated in this manner: The great sinus of the falx, or superior longitudinal sinus, which was reckoned the first by the ancients. Two great lateral sinuses, the second and third of the ancients. The sinus, called *torcular Herophili*, the fourth of the ancients. The small sinus of the falx, or inferior longitudinal sinus. The posterior occipital sinus, which is sometimes double. Four sinus petrosi; two on each side, one superior, and

and one inferior. Two transverse occipital sinuses, The circular sinus of the sella sphenoidalis. Two sinus cavernosi, one on each side. Two orbital sinuses, one on each side.

All these sinuses communicate with each other, and with the great lateral sinuses, by which they discharge themselves into the internal jugular veins, which are only continuations of these lateral sinuses. They likewise unload themselves, partly into the vertebral veins, which communicate with the small lateral or inferior occipital sinuses; and partly into the external jugular veins, by the orbital sinuses, which communicate with the *venæ angulares, frontales, nasales, maxillares, &c.* as the lateral sinuses likewise communicate with the *venæ occipitales, &c.*

Thus the blood, which is carried to the dura mater, &c. by the external and internal carotid, and by the vertebral arteries, is returned to the heart by the external and internal jugular and vertebral veins; so that, when the passage of the blood is obstructed in any particular place, it finds another way by virtue of these communications, though not with the same ease. This observation is of consequence, in relation not only to obstructions, but to the different situations of the head.

The great sinus of the falx reaches from the connection of the ethmoidal crista with the os frontis, along the upper edge of the falx, all the way to the posterior edge of the transverse septum, where it ends by a bifurcation in the great lateral sinuses. It is very narrow at its anterior extremity, and from thence becomes gradually wider all the way to its posterior extremity.

The cavity of this sinus is not cylindrical, but triangular, having in a manner three sides; one superior, parallel to the cranium; and two lateral, inclined to the plane of the falx. The upper side is formed by the external surface of the dura mater; and through the

the middle of its breadth a kind of fine raphe or suture runs from one end to the other.

The two lower or lateral sides are productions of the inner surface of the dura mater; which having parted from the external, are inclined toward each other, and then unite; forming first the sinus, and afterwards the duplicature of the falx. This sinus is lined interiorly by a fine proper membrane, which forms likewise a kind of raphe or suture along the bottom of the sinus, that is, along the union of the two lateral sides.

In this sinus we observe several openings and several ligamentary fræna. The openings are orifices of veins; the smallest of which belong to the dura mater, the largest to the brain. The veins of the brain enter the sinus for the most part, obliquely from behind forward, after they have run about a finger's breadth in the duplicature of the dura mater.

It has been thought that the arteries of the dura mater discharged themselves immediately into the sinuses; because injections made by the arteries, or a hog's bristle thrust into them, have been found to pass into these sinuses: but, on a more close examination, it has been discovered, that the injections passed from the arteries into the veins, and from thence into the sinuses, through the small orifices already mentioned; and that the hog's bristle pierced the sides of the artery, which near the sinuses are very thin.

This mistake gave rise to another, that the dura mater had no veins; and what confirmed it was, that the arteries of the dura mater cover the veins so entirely, that the edges of the veins are hardly perceivable on either side of the arteries. There are, however, some places where the veins being broader than the arteries, their two edges are seen on each side of the arteries like capillary vessels. These veins are, for the most part, branches of the sinuses; and the small trunks of
some

some of them open into the head of the vena jugularis interna. We may easily be satisfied that the arteries on both sides of the dura mater communicate with each other above the falx, either by injecting or blowing into them.

The internal fræna of this great sinus appear to be tendinous, and to be designed to prevent the too great dilatation of the sinus by the blood. They vary, however, in different subjects, and do not always reach from one side to the other. It has been pretended, that glands have been found there; but we ought to take care not to mistake for such certain small corpuscles, which seem to have about them very little of the nature of glands.

The inferior sinus of the falx is situated in the lower edge of its duplicature, being very narrow, and, as it were, flattened on both sides. It communicates immediately with the fourth sinus of the ancients; and in some subjects seems even to be a continuation thereof. It likewise communicates with the great or superior sinus by small veins which go from one to the other, and with the veins of the cerebrum by the same means.

The lateral sinuses represent two large branches of the superior longitudinal sinus, one going to the right hand, the other to the left, along the great circumference of the transverse septum, all the way to the basis of the apophysis petrosa of the ossa temporum. From thence they run down, having first taken a large turn, and then a small one; and being strongly fixed in the lateral grooves of the basis cranii, they follow the course thereof all the way to the foramina lacera and fossulæ of the jugular veins.

They do not always arise by an equal bifurcation of the superior longitudinal sinus; for, in some subjects, one of the lateral sinuses appears to be a continuation of the longitudinal, and the other to be a branch from it. This variety may happen on either side; and, in

a word, we sometimes find one of these sinuses higher or lower, larger or smaller, than the other.

The cavity of these lateral sinuses is likewise triangular, and furnished with a proper membrane and with fræna: and it has also the small venal openings; which indeed are common to it, not only with the longitudinal sinus, but with most part of the others. The posterior or outer side of this cavity, is formed by the external part of the dura mater, and the other two by the internal part.

As these two sinuses go out by the posterior portions of the openings of the basis cranii, called *foramina laceræ*, they are dilated into a kind of bag, proportioned to the fossulæ of the venæ jugulares, where they terminate in these veins.

Near the concurrence of the superior longitudinal and lateral sinuses, we observe an opening (sometimes double), which is the orifice of a sinus situated along the union of the falx and transverse septum. It does not always end directly at the lower part of the superior sinus, but sometimes opens at the beginning of one of the lateral sinuses, especially when the bifurcation is not equal; and in this case it often terminates in that lateral sinus, which appears like a branch from the common trunk of the superior and other lateral sinus.

This sinus has been named *torcular Heropholi*, from an ancient author, who imagined that the blood was in a manner in a press, at the union of these four sinuses. Its diameter is but small; and it forms a kind of bifurcation with the inferior longitudinal sinus, and with a vein of the cerebrum, which is sometimes double, called *vena magna Galeni*.

The cavernous or lateral sinuses of the os sphenoides, are reservatories of a very particular kind; containing not only blood, but considerable vessels and nerves, as we shall see hereafter; and likewise a spongy or cavernous

nous substance full of blood, much like that of the corpus cavernosum of the urethra.

Nerves and glands. We observe some nervous filaments which appear to go to the dura mater from the trunk of the fifth pair, at the entry of the cavernous sinus; and from the common trunk of the eighth pair and nervus accessorius or spinalis, as they pass through the foramen lacerum; and inflammation, as well as surgical phenomena, show that it is not void of sensibility, though, in the sound state, this is not very obvious. The small tubercles found on the lateral sides of the longitudinal sinus of the falx and contiguous parts of the brain, deserve still to be examined before we can determine any thing about them: They have been called *glands* by Pacchioni, and seem to belong rather to the conglomerate than to the conglobate kind. The whole inside of the dura mater is moistened in the same manner as the peritonæum and pleura.

The prominent fibres intersecting each other in different manners which appear on the inside of the dura mater, especially near the falx and transverse septum, and which have been taken for a kind of fleshy fibres, seem to be only ligamentary and elastic. The universal adhesion of this membrane to the cranium, proves that it can have no particular motion, and consequently that such fleshy or muscular fibres would be altogether useless. This adhesion was plainly demonstrated by Vesalius, Riolan, &c. long before Roonhuysen.

§ 2. *Pia Mater.*

Situation in general. This membrane is a much softer and finer substance than the former; being exceedingly delicate, transparent, and vascular; and is connected to the dura mater only by the veins which open into the sinuses as has been already said.

Structure. It is composed of two laminæ, of which

which the external one is named *tunica arachnoidea*, from its resemblance to a cobweb. They adhere closely to each other at the upper part of the brain; but are easily separable at the basis, and through the whole length of the spinal marrow.

The *tunica arachnoidea* is a remarkably thin and transparent membrane, having no vessels that can be injected entering into its composition. It is spread uniformly over the surface of the brain, inclosing all the circumvolutions, but without entering in between any of them; while the *pia mater*, or internal lamina, forms a great number of *plicæ*, duplicatures, and *sep-ta*; which not only cover the brain in general, but insinuate themselves into all the folds and circumvolutions, and between the different strata of the cerebrum and cerebellum, and are likewise continued into the different cavities.

The two laminae of the *pia mater* are connected by a cellular substance, which accompanies them through their whole extent, except at some places of the basis of the cerebrum, &c. where, the internal lamina continuing its insertions, the external remains uniformly stretched over the prominent parts, the interstices of which are entirely separated from the other lamina without any cellular substance between them. These separate portions of the external lamina have made it be looked upon as a third membrane of the brain, distinct from the *pia mater*.

§ 3. *Cerebrum*.

Situation and figure. THE cerebrum, properly so called, is a kind of medullary mass, of a moderate consistence, and of a greyish colour on the outer surface, filling all the superior portion of the cavity of the cranium, or that portion which lies above the transverse septum. The upper part of the cerebrum is of an oval figure, like half an egg cut lengthwise, or rather like

two quarters of an egg cut lengthwise, and parted a little from each other. It is flatter on the lower part, each lateral half of which is divided into three eminences, which correspond with the cavities at the base of the cranium.

Division and lobes. The cerebrum is divided into two lateral portions, separated by the falx, or great longitudinal septum of the dura mater. They are generally termed *hemispheres*, but they are more like quarters of an oblong spheroid. Each of these portions is divided into two extremities, one anterior, and one posterior, which are termed the *lobes of the cerebrum*, between which there is a large inferior protuberance which goes by the same name; so that in each hemisphere there are three lobes, one anterior, one middle, and one posterior.

The anterior lobes lie upon those parts of the os frontis which contribute to the formation of the orbits and of the frontal sinuses, commonly called the *anterior fossæ of the basis cranii*. The middle lobes lie in the middle or lateral fossæ of the basis cranii, and the posterior lobes on the transverse septum of the dura mater. The anterior and middle lobes of the cerebrum on each side are parted by a deep narrow sulcus, which ascends obliquely backward, from the temporal ala of the os sphenoides to near the middle of the os parietale; and the two sides of this division have each their particular ridges and convolutions, which gives a very great extent to the cortical substance. This sulcus is termed *fissura magna sylvii*, or simply *fissura cerebri*.

Sides and inequalities. Each lateral portion of the cerebrum has three sides; one superior, which is convex; one inferior, which is uneven; and one lateral, which is flat, and turned to the falx. Through the whole surface of these three sides we see inequalities or windings like the circumvolutions of intestines, formed by weaving streaks or furrows very deep and narrow, into which the septa or duplicatures of the pia mater

infi-

insinuate themselves, and thereby separate these circumvolutions from each other.

Near the surface of the cerebrum, these circumvolutions are at some distance from each other, representing serpentine ridges; and in the interstices between them, the superficial veins of the cerebrum are lodged, between the two laminæ of the pia mater, from whence they pass into the duplicature of the dura mater, and so open into the sinuses.

These circumvolutions are fixed through their whole depth to the septa or duplicatures of the pia mater, by an infinite number of very fine vascular filaments, as may be seen by pulling the circumvolutions a little asunder with the fingers.

When we cut transversely, we observe that the *substantia alba* lies not only in the inner part of the brain in general, but also within each circumvolution, so that there is the same number of internal medullary circumvolutions as of external cortical ones; the first representing white laminæ invested by others of an ash-colour; but the cortical substance is in many places thicker than the medullary.

Substance. The substance of the cerebrum is of two kinds, distinguished by two different colours; one part of it being of a greyish or ash-colour; the other, which is somewhat firmer than the former, is remarkably white, but redder in the foetus. The ash-coloured substance lies chiefly on the outer part of the cerebrum like a kind of cortex, from whence it has been named *substantia corticalis* or *cinerea*. The white substance occupies the inner part, and is named *substantia medullaris*, or simply *substantia alba*. This abounds in greater quantity than the other, and in many places is perforated with red arteries.

Corpus callosum. Having cut off the falx from the *crista galli*, and turned it backward; if we separate gently the two lateral parts or hemispheres of the cerebrum, we see a longitudinal portion of a white convex body

body which is named *corpus callosum*. It is a middle portion of the medullary substance, which under the inferior sinus of the falx, and also a little toward each side, is parted from the mass of the cerebrum, to which it is simply contiguous from one end of that sinus to the other; so that, at this place, the edge of the inside of each hemisphere only lies on the corpus callosum, much in the same manner as the anterior and posterior lobes lie on the dura mater. Both extremities of this medullary body terminate by a small edge bent transversely downward.

The surface of the corpus callosum is covered by the pia mater, which runs in between the lateral portions of this body and the lower edge of each hemisphere. Along the middle of its surface from one end to the other, there is a kind of raphe formed by a particular intertexture of fibres which cross each other. This raphe is made more perceivable by two small medullary cords which accompany it on each side, and adhere closely to the transverse fibres. The same striated appearance is to be observed in the inner parts of this substance.

Medullary arch and centrum ovale. The corpus callosum becomes afterwards continuous on each side with the medullary substance; which, through all the remaining parts of its extent, is entirely united with the cortical substance, and together with the corpus callosum forms a medullary arch or vault of an oblong or oval figure. To perceive this, the whole cortical substance, together with the medullary laminæ mixed with it, must be cautiously and dexterously cut in the same direction with the convexity of the cerebrum. After which we will observe a medullary convexity much smaller than that which is common to the whole cerebrum, but of the same form; so that it appears like a medullary nucleus of the cerebrum, especially when we consider it together with the medullary substance of the inferior part or basis of the cerebrum; for the deeper we go the medullary part becomes the broader. And from

thence M. Vieussens took occasion to name this nucleus the *centrum ovale*.

Ventriculi laterales. Under this arch are two lateral cavities, much longer than they are broad, and very shallow, separated by a transparent medullary septum; of which hereafter. These cavities are generally named the *anterior superior ventricles of the cerebrum*, to distinguish them from two other smaller cavities which are situated more backward, as we shall see presently; but the name of *lateral* or *great ventricles* given them by Steno, is more proper than either of the other two.

The lateral ventricles are broad, and rounded at those extremities which lie next the transparent septum. They go from before backward, contracting in breadth, and separating from each other gradually in their progress. Afterwards they bend downward, and return obliquely from behind forward, in a course like the turning of a ram's horn, and terminate almost under their superior extremities, only a little more backward and outward.

At the posterior part where they begin to bend downward, there is on each side a particular elongation, which runs backward, and terminates in a triangular pointed cavity turned a little inward, the two points resembling horns. These ventricles are every where lined with a continuation of the pia mater.

Septum lucidum. The transparent partition, or *septum lucidum*, as it is commonly called, lies directly under the raphe or suture of the corpus callosum, of which it is a continuation and a kind of duplicature. It is made up of two medullary laminæ, more or less separated from each other by a narrow medullary cavity, sometimes filled with a serous substance. This cavity, in some subjects, reaches a great way backward, and seems to communicate with the third ventricle; and in cases of internal hydrocephalus, has been found full of water as well as the other cavities of the brain.

Fornix. The septum lucidum is united, by its lower part,

part, to the anterior portion of that particular medullary body, called improperly *the fornix* with three pillars; because of some resemblance it is thought to bear to the arches of ancient vaults. It is in reality nothing but the corpus callosum; the lower side of which is like a hollow ceiling with three angles, one anterior and two posterior; and three edges, two lateral and one posterior. The lateral edges are terminated each by a large semicylindrical border, like two arches; which uniting at the anterior angle, form by their union what is called *the anterior pillar of the fornix*; and as they run backward separately toward the two posterior angles, they have then the name of *the posterior pillars*.

The anterior pillar being double, is larger than either of the posterior; and the marks of this duplicity always remain. Immediately below the basis of this pillar we observe a large, white, short, medullary rope stretched transversely between the two hemispheres, and commonly called *the anterior commissure of the cerebrum*. It is to this pillar that the septum lucidum adheres. The posterior pillars are bent downward, and continued through the lower portions of the ventricles all the way to their extremities, resembling a ram's horn, which is a name that has been given to them. They diminish gradually in thickness during this course; and at their outsides they have each a small, thin, flat, collateral border, to which the name of *corpora fimbriata* is applied.

The posterior pillars of the crura of the fornix unite with two medullary protuberances called *pedes hippocampi*.—The inferior surface of the triangular ceiling, which lies between these arches, is full of transverse, prominent medullary lines; for which reason the ancients called it *psaloides* and *lyra*, comparing it to a stringed instrument, something like what is now called a *dulcimer*.

Under the fornix, and immediately behind its an-
C 2 terior

terior crura, there is a hole of a considerable size, by which the two lateral ventricles communicate (*See* *Monro on the Nervous System*, *Tab. IV.*); and another passage leads down from this, under the different appellations of *foramen commune anterius*, *vulva*, *iter ad infundibulum*, but more properly *iter ad tertium ventriculum*.

Eminences. The fornix being cut off and inverted, or quite removed, we see first of all a vascular web, called *plexus choroides*, and several eminences more or less covered by the expansion of that plexus. There are four pairs of eminences which follow each other very regularly, two large and two small. The first two great eminences are named *corpora striata*; and the second, *thalami nervorum opticorum*. The four small eminences are closely united together; the anterior being called *nates*, and the posterior *testes*; but it would be better to call them simply *anterior* and *posterior tubercles*. Immediately before these tubercles there is a single eminence, called *glandula pinealis*.

Corpora striata. The corpora striata got that name, because in cutting them with the knife we meet with a great number of white and ash-coloured lines alternately disposed, which are only the transverse section of the medullary and cortical laminæ mixed together in a vertical position in the basis of the cerebrum, as appears evidently by incisions made from above downward. These two eminences are of a greyish colour on the surface, oblong, roundish, pyriform, and larger on the fore than on the back part, where they are narrow and bent.

They lie in the bottom of the superior cavity of the lateral ventricles, which they resemble in some measure in shape, their anterior parts being near the septum lucidum, from which they separate gradually as they run backward, and diminish in size. They are in reality the convex bottoms of the ventricles; and it is at the lower part of the interstice between the largest portions

tions of them, that we observe the greatest transverse cord, named *the anterior commissure of the cerebrum*, which we mentioned already in describing the anterior pillar of the fornix callosus. This cord communicates more particularly with the bottom of the corpora striata, by a turn toward each side.

Thalami nervorum opticorum. The thalami nervorum opticorum, are so named, because these nerves arise chiefly from them. They are two large eminences placed by the side of each other, between the posterior portions or extremities of the corpora striata. Their figure is semispheroidal and a little oval; and they are of a whitish colour on the surface; but their inner substance is partly greyish and partly white, so that, in cutting them, we see streaks of different colours like those of the corpora striata.

These two eminences are closely joined together; and at their convex part they are so far united, as really to become one body, the whitish outer substance being continued uniformly over them both.

At the bottom these two eminences are elongated downward toward both sides, into two thick, round, whitish cords, which separate from each other like horns by a large curvature; and afterwards, by a small curvature turned forward in an opposite direction to the former, and representing the tip of an horn, they approach each other again. The size of these nerves diminishes gradually from their origin to their anterior reunion. We shall have occasion to mention them in another place in speaking of the optic nerves.

Third Ventricle. Immediately under the union or beginning of the thalami nervorum opticorum, lies a particular cavity, called the *third ventricle* of the cerebrum. This cavity communicates at its upper and fore-part with the passage between the two lateral ventricles, and sends down from its under and fore part a passage through the infundibulum. It opens backwards into the passage called *iter ad quartum ventriculum*.

Infundibulum. Between the basis of the anterior pillar of the fornix and the anterior part of the union of the optic thalami, lies a small medullary canal, named *infundibulum*. It runs down towards the basis of the cerebrum, contracting gradually, and terminates in a straight course by a small membranous canal, in a softish body situated in the sella turcica, named *glandula pituitaria*.

Plexus choroides. The plexus choroides is a very fine vascular texture, consisting of a great number of arterial and venal ramifications, partly collected in two loose fasciculi, which lie on each lateral ventricle, and partly expanded over the neighbouring parts, and covering in a particular manner the thalami nervorum opticorum, *glandula pinealis*, *tubercula quadrigemina*, and the other adjacent parts both of the cerebrum and cerebellum, to all which it adheres.

In each lateral portion of this plexus we observe a venal trunk; the ramifications of which are spread through the whole extent of the two portions. Near the *glandula pinealis* these two trunks approach each other; and uniting behind that gland, they open into the torcular or fourth sinus of the dura mater. When we blow into one of these trunks toward the plexus, the air passes into all its ramifications; and in some subjects, these two veins form one trunk which opens into the sinus.

The ventricular or loose portions of the plexus often appear to contain a great number of tubercles like glands; which in the natural state are extremely small, but grow bigger in diseases. To be able to examine them as we ought, the loose portions must be made to swim in clear water, and be there carefully expanded. Then, by the help of a microscope, we will see these tubercles in the natural state, like small folliculi or little bags more or less flattened.

Besides this vascular web or plexus of the septum lucidum, the sides of the fornix, of the eminences, ventricles, canals, and *infundibulum*, are all covered by a
very

very fine membrane, in which, by injections or inflammations, we discover a great number of very fine vessels. This membrane is in a manner a continuation of the plexus, and that seems to be a detachment from the pia mater. By the same means we likewise discover an extremely thin membrane on the insides of the duplicature of the septum, though, in some subjects, these sides touch each other.

Glandula pituitaria. The pituitary gland is a small spongy body lodged in the sella turcica, between the sphenoidal folds of the dura mater. It is of a singular kind of substance, which seems to be neither medullary nor glandular. On the outside it is partly greyish and partly reddish, and white within. It is transversely oval or oblong; and on the lower part, in some subjects, it is divided by a small notch into two lobes, like a kidney bean. It is covered by the pia mater as by a bag, the opening of which is the extremity of the infundibulum; and it is surrounded by the small circular sinuses which communicate with the sinus cavernosi.

Tubercula. The tubercles are four in number, two anterior and two posterior; adhering together as if they made but one body situated behind the union of the thalami nervorum opticorum. They are transversely oblong; the anterior being a little more rounded, and broader or larger from before backward, than the posterior. Their surface is white, and their inner substance greyish. The names of *nates* and *testes*, given by the ancients to these tubercles, are not very proper, there being no great resemblance between them and the things from which the names are taken. Some of the moderns, with perhaps still less propriety, have called them *tubercula quadrigemina*. We shall use the names, however, as we find them.

Directly under the place where the tubercles of one side are united to those of the other side, lies the *iter ad quartum ventriculum*, which communicates by its anterior opening with the third ventricle, under the

thalami nervorum opticom, and, by its posterior opening, with the fourth ventricle, which belongs to the cerebellum.

Foramen commune posterius. Where the convex parts of the two anterior tubercles join these posterior convex parts of the thalami nervorum opticom, an interfice or opening is left between these four convexities; but it does not communicate with the third ventricle: for the bottom of it is shut up by the pia mater. It has got the name of *anus* applied to it.

Glandula pinealis. The glandula pinealis is a small soft greyish body, about the size of an ordinary pea, irregularly round, and sometimes of the figure of a pine-apple, situated behind the thalami nervorum opticom above the tubercula quadrigemina. It is fixed like a small button to the lower part of the thalami by two very white medullary pedunculi, which at the gland are very near each other, but separate almost transversely toward the thalami.

It seems to be mostly of a cortical substance, except near the footstalks, where it is somewhat medullary. The footstalks are sometimes double, as if they belonged to the two anterior tubercles. This body adheres very close to the plexus choroides, by which it is covered, as we shall see hereafter; and it therefore requires some dexterity to separate it from the glandula, without altering its situation or breaking the pedunculi. This gland has been often found to contain gravel. Below the glandula pinealis there is a medullary transverse cord, called the *posterior commissure of the hemispheres of the cerebrum*.

§ 4. Cerebellum.

Situation and figure. The cerebellum is contained under the transverse septum of the dura mater, in the under and back part of the cranium. It is broader laterally than on the fore or back sides, flatted on the upper

upper side, and gently inclined both ways, answerable to the septum, which serves it as a kind of tent or ceiling. On the lower side it is rounder; and on the back side it is divided into two lobes, separated by the occipital septum of the dura mater.

Structure. It is made up, like the cerebrum, of two substances, but it has no circumvolutions on its surface. In place of these it has numerous sulci, which are pretty deep, and disposed in such a manner as to form thin flat strata, more or less horizontal, between which the internal lamina of the pia mater insinuates itself by a number of septa equal to that of the strata.

Under the transverse septum, it is covered by a vascular texture, which communicates with the plexus choroides. It has two middle eminences called *appendices vermiformes*; one anterior and superior, which is turned forward; the other posterior and inferior, which goes backward. There are likewise two lateral appendices, both turned outward. They are termed *vermiformes*, from their resemblance to a large portion of an earth-worm.

Besides the division of the cerebellum into lateral portions, or into two lobes, each of these lobes seems to be likewise subdivided into three protuberances, one anterior, one middle or lateral, and one posterior: but they are not in all subjects equally distinguished either by their convexity or limits; but they may always be distinguished by the direction of their strata, those of the middle and anterior protuberance being less transverse than the posterior.

Fourth Ventricle. When we separate the two lateral portions or lobes, having first made a pretty deep incision, we discover, first of all, the posterior portion of the medulla oblongata, of which hereafter; and in the posterior surface of this portion, from the tubercula quadrigemina, all the way to the posterior notch in the body of the cerebellum, and a little below that notch, we observe an oblong cavity, which is called the *fourth ven-*

ventricle; this terminates backward like the point of a writing pen. Hence the under end of it is called *calamus scriptorius*.

At the beginning of this cavity we meet with a thin medullary lamina, which is looked upon as a valve between that canal and the fourth ventricle. A little behind this lamina, the cavity grows wider towards both sides, and then contracts again to its first size. It is lined interiorly by a thin membrane, and seems often to be distinguished into two lateral parts, by a kind of small groove, from the valvular lamina to the point of the *calamus scriptorius*.

This membrane is a continuation of that part of the pia mater which lines the small canal, the third ventricle, infundibulum, and the two great ventricles. To be able to see the fourth ventricle in its natural state, in which it is narrowest, it must be laid open while the cerebellum remains in the cranium; and in order to that, the os occipitis must be sawed very low down.

On each side of this ventricle, the medullary substance forms a trunk which expands itself in form of laminae through the cortical strata. But here we find the medullary bearing a less proportion to the cortical than it does in the cerebrum. We discover these medullary laminae according to their breadth, by cutting the cerebellum in slices almost parallel to the basis of the cerebrum; but if we cut one lobe of the cerebellum vertically from above downward, the medullary substance will appear to be dispersed in ramifications through the cortical substance. These ramifications have been named *arbor vitae*, and the two trunks from whence these different laminae arise are called *pedunculi cerebelli*.

We cannot go on with the description of the other middle parts of the basis of the cerebellum, before that of the middle parts of the basis of the cerebrum; because these two kinds of parts are united, and jointly form

form the medulla oblongata. We shall only add here, that the strata of both substances of the cerebellum are not always of the same extent in the same portions or protuberances of each lobe. This appears merely by viewing the convex or outer surface of the cerebellum; for there we see, at different distances, some cortical strata shorter than others, and likewise that the extremities of the short strata diminish gradually in thickness till they are quite lost between two long ones.

If we make a small hole in the external lamina of the pia mater over one of the lobes of the cerebellum, without touching the inner lamina, and then blow into the cellular substance, by which these two laminæ are connected, through a small pipe introduced into the hole; the air will gradually swell that substance, and separate the strata more or less equally from each other through their whole extent; and we will see at the same time the disposition of all the membranous septa or duplicatures of the internal lamina of the pia mater, with the numerous distribution of the fine blood-vessels which run upon it, especially after a lucky injection, or in an inflammatory state of these membranes.

§ 5. *Medulla oblongata.*

THE medulla oblongata is a medullary substance, situated from before backward in the middle part of the bases of the cerebrum and cerebellum, without any discontinuation, between the lateral parts of both these bases: and therefore it may be looked upon as one middle medullary basis common to both cerebrum and cerebellum, by the reciprocal continuity of their medullary substances, through the great notch in the transverse septum of the dura mater; which common basis lies immediately on that portion of the dura mater which lines the basis of the cranium. The medulla oblongata is therefore justly esteemed to be a
third

third general part of the whole mass of the brain; or as the common production or united elongation of the whole medullary substance of the cerebrum and cerebellum.

It is extremely difficult, if not altogether impossible, to examine or demonstrate it as we ought, in its natural situation; but we are obliged to do both on a brain inverted.

The lower side of the medulla oblongata, in an inverted situation, presents to our view several parts, which are in general either medullary productions, trunks of nerves, or trunks of blood-vessels.

The chief medullary productions are these; the large or anterior branches of the medulla oblongata, which have likewise been named *crura anteriora*, *femora* and *brachia medullæ oblongatæ*, and *pedunculi cerebri*: the transverse protuberance, called likewise *processus annularis* or *pons Varolii*: the small or posterior branches, called *pendunculi cerebelli*, or *crura posteriora medullæ oblongatæ*: the extremity or cauda of the medulla oblongata, with two pairs of tubercles; one of which is named *corpora olivaria*, the other *corpora pyramidalia*; and to all these productions we must add a production of the infundibulum and two medullary papillæ.

The great branches of the medulla oblongata are two very considerable medullary fasciculi; the anterior extremities of which are separated, and the posterior united, so that, taken together, they somewhat represent a Roman V. These fasciculi are flat, much broader before than behind; their surfaces being composed of several longitudinal and distinctly prominent medullary fibres. Their anterior extremities seem to be lost at the lower part of the corpora striata; and it is for that reason that they are looked upon as the pedunculi of the cerebrum.

The transverse annular, or rather semi-annular, protuberance, is a medullary production, which seems at first sight to surround the posterior extremities of the great

great branches; but the medullary substance of this protuberance is in reality intimately mixed with that of the two former. Varolius, an ancient Italian author, viewing those parts in an inverted situation, compared the two branches to two rivers, and the protuberance to a bridge over them both; and from thence it has the name of *pons Varolii*. Its surface is transversely streaked; and it is divided into two lateral parts by a very narrow longitudinal depression, which does not penetrate into its substance. When we cut into the substance of the pons, we find much cortical substance within it, and this formed into *striæ*, which run in various directions. And the same thing will be found with respect to the medullary part of the brain; for there is scarcely any part of it but what has cortical *striæ* running through it. See *Monro's Observations on the Nervous System*, Tab. VII.

The small branches of the medulla oblongata are lateral productions of the transverse protuberance, which by their roots seem to encompass that medullary portion in which the fourth ventricle or calamus scriptorius is formed. They form in the lobes of the cerebellum, on each side, these medullary expansions, a vertical section of which shows the white ramifications commonly called *arbor vitæ*; and they may be justly enough styled *pedunculi cerebelli*.

The extremity is no more than the medulla oblongata contracted in its passage backward to the anterior edge of the foramen magnum of the os occipitis, where it terminates in the medulla spinalis; and in this part of it several things are to be taken notice of. We see first of all, four eminences, two named *corpora olivaria*, and the other two *corpora pyramidalia*. Immediately afterwards, it is divided into two lateral portions by two narrow grooves, one on the upper side, the other on the lower. They both run into the substance of the medulla, as between two cylinders, flattened on that side by which they are joined together.

When

When we separate these ridges with the fingers, we observe a crucial intertexture of several small medullary cords, which go obliquely from the substance of one lateral portion into the substance of the other. M. Petit, member of the Royal Academy of Sciences and doctor of physic, is the author of this discovery, by which we are enabled to explain several phænomena both in physiology and pathology; of which in another place.

The corpora olivaria and pyramidalia are whitish eminences situated longitudinally near each other on the lower side of the extremity or cauda, immediately behind the transverse or annular protuberances. The corpora pyramidalia are in the middle; so that the interstice between them, which is only a kind of superficial groove, answers to the inferior groove of the following portion.

The corpora olivaria are two lateral eminences situated at the outside of the former, and are thus termed by Willis, Duverney, Haller, &c. but Winslow reverses the names. These four eminences are situated on the lower half of the medulla; which observation we here repeat, to make it be remembered, that, in all the figures and demonstrations, these parts are represented as superior, which in their natural situation are inferior. Thus these eminences are under the fourth ventricle, and under the pedunculi cerebelli.

The tubercula mammillaria, which are situated very near the production of the infundibulum, have been taken for glands; probably because of their greyish inner substance, which, however, does not seem to be different from that of several other eminences of the medulla oblongata. And for that reason we choose rather to call them, from their figure, *tubercula mammillaria*, than *papillæ medullares*.

These tubercles seem to have some immediate relation to the roots or bases of the anterior pillar of the fornix; so that they might be named, as M. Santorini
has

has done, *the bulbs of these roots*, though they appear to be likewise partly a continuation of other portions of the cortical and medullary substance, of a particular texture.

The beak or tube of the infundibulum is a very thin production from the sides of that cavity; and it is strengthened by a particular coat given to it by the pia mater. It is bent a little from behind forward, toward the glandula petuitaria, and afterwards expands again round this gland.

The membrana arachnoides, or external lamina of the pia mater, appears to be very distinctly separated from the internal lamina, in the interstices between all these eminences on the lower side of the medulla oblongata, without any visible cellular substance between them. The internal lamina adheres much more to the surface of these interstices than to that of the eminences. The external lamina is as it were buoyed up by the eminences, and equally stretched between their most prominent parts, to which it sticks very close; and in this respect the roots or great cornua of the optic nerves may be joined to these eminences.

We must observe in general concerning the eminences of the medulla oblongata, that those which are medullary on their outsides or surfaces, are interiorly either entirely cortical, or partly cortical and partly medullary, or formed by a singular mixture of these two substances, which still remains to be unfolded, as well as many other particularities observable in examining the internal structure of the brain.

From this common portion of the cerebrum and cerebellum, arise almost all the nerves which go out of the cranium, through the different foramina by which its basis is perforated. It likewise produces the medulla spinalis, which is no more than a common elongation of the cerebrum and cerebellum, and of their different substances; and therefore the medulla oblongata may justly be said to be the first origin or primitive

tive source of all the nerves which go out through the spina dorsi, and consequently of all the nerves of the human body.

§ 6. *Medulla spinalis.*

THE medulla spinalis is only an elongation of the extremity of the medulla oblongata; and it has its name from its being contained in the bony canal of the spina dorsi. It is consequently a continuation or common appendix of the cerebrum and cerebellum, as well because of the two substances of which it is composed, as because of the membranes by which it is invested.

In the description of the fresh bones, mention was made of a ligamentary substance which lines the inner surface of this bony canal from the great occipital foramen to the os sacrum. Besides this, the dura mater, after it has lined the whole internal surface of the cranium, goes out by the foramen magnum occipitis; and forms a kind of funnel, in its progress downward, through the bony canal of the vertebræ. As it goes out at the occipital hole, it joins the beginning of the ligamentary funnel already mentioned, and adheres very strongly to it. That portion of the pericranium which terminates exteriorly at the edge of the great foramen, joins the funnel likewise; which by all these successions becomes very strong, and capable of resisting the greatest violences.

This adhesion of the dura mater to the ligamentary funnel is gradually discontinued below the first vertebra; and from thence the dura mater forms a separate tube, which runs down in the bony canal all the way to the os sacrum, the capacity of it answering to that of the canal; but it does not adhere closely to the sides, as it does to that of the cranium. It is surrounded by a slimy substance, which, near the lower end of the canal, resembles fat.

The spinal marrow is made up of a cortical and medullary substance, as the cerebrum and cerebellum; but with this difference, that the ash-coloured substance lies within the other; and in a transverse section of this medulla the inner substance is somewhat of an oblong form, but has its sides bent inwards.

The body of the medulla spinalis runs down all the way to the bottom of the first vertebra of the loins, where it terminates in a point. The size of it is proportionable to that of the bony canal; so that it is larger in the vertebræ of the neck than those of the back. It is a little flattened on the fore and back parts; so that we may distinguish in it two sides, one anterior, the other posterior, and two edges. It is likewise in a manner divided into two lateral halves or cords by a groove, which runs along the middle of its anterior and posterior surfaces, being a continuation of those in the extremity of the medulla oblongata. The cords are applied closely together, but may be readily separated before as well as behind till we come to their middle or deepest part, where they are joined together by a thin layer of cineritious substance passing from the one cord into the other.

Each lateral portion sends off from both the fore and back sides, between the grooves and the edges, at different distances, flat fasciculi of nervous filaments turned toward the nearest edge. The anterior and posterior fasciculi are separated from each other by the *ligamentum denticulatum*; then passing outwards, they go through the dura mater by two distinct openings though very near each other. Having penetrated the dura mater, the posterior bundle forms a ganglion; from the opposite end of which the trunk comes out again, and is there joined by the anterior bundle.

The dura mater which invests the medulla, sends out on each side the same number of *vaginæ*, as there are ganglions and nervous trunks. These *vaginæ* are productions of the external part of this membrane; the

internal part, which is very smooth and polished on the inside, being perforated by two small holes very near each other, where each vagina goes off, through which holes the anterior and posterior fasciculi are transmitted; and immediately after their passage through the internal part, they unite.

The triangular spaces left between the anterior and posterior fasciculi and edge of the medulla, are filled from one extremity to the other by an indented ligament, very thin and shining, having the same number of indentations as there are pairs of fasciculi. It is closely connected by numerous threads to the pia mater at each side of the medulla, while the opposite side sends out indentations, the greater number of which run transversely, though others go obliquely upwards or downwards; and all of them, after being split into threads, are fixed to the inner side of the dura mater. The under end of the ligamentum denticulatum, runs as far as the os coccygis, and is what authors have considered as the fortieth pair of nerves*; from whence it sends filaments to the internal part of the dura mater, by which the anterior fasciculi are distinguished from the posterior.

The membrana arachnoides is here very distinct from the internal lamina of the pia mater: so that, by blowing through a hole made in the arachnoides, it will swell from one end to the other, like a transparent gut. The internal lamina, called in this place simply the *pia mater*, adheres very closely to the medulla spinalis, and sends many productions and septa through its substance. When we blow through a hole made in the pia mater, through the substance of one lateral portion of the medulla, the air penetrates through the whole, and the pia mater, which covers the other lateral portion, is separated from it.

The membrana arachnoides adheres here more closely to the pia mater at the lower than at the upper part, being

* For this and the three preceding paragraphs, see *Monro on the Nervous System*, Tab. IX. X. XVII. &c.

being in a manner suspended by the indented ligament which runs along both edges of the medulla, and is fixed by a filament to the internal lamina of the dura mater in each interstice between the nervous fasciculi, as has been already said. It also gives off elongations in the same manner as the dura mater to each nervous trunk or rope, as we shall see hereafter.

§ 7. *The Nerves of the Brain and Spinal Marrow, from their origin to their going out of the Cranium and Spine.*

WE shall afterward find, that the nerves arise either from the brain, medulla oblongata, or spinalis; that they go out in fasciculi disposed in pairs; but they may be divided into three classes, viz. nerves, which pass through the cranium; nerves immediately from the spinal marrow; and nerves from the brain and spinal marrow; to which last class belongs the great sympathetic nerve. Ten pairs are reckoned to belong to the brain and medulla oblongata, of which nine go out through the foramina of the cranium, and the tenth arises from the extremity of this medulla as it passes through the great occipital hole; and lastly, that 29 pairs are reckoned to belong to the medulla spinalis, of which seven pass through the lateral notches of the vertebræ cervicis, twelve through those of the back, five through those of the loins, and five through the anterior holes of the os sacrum.

Our design is here principally to mention some particular observations about the nerves, while they remain within the bones; the rest of the course through the whole body shall be afterward sufficiently described.

Nerves of the brain. The first pair of nerves that arise from the brain are the olfactory, anciently called *processus mammillares*. These are two very flat and soft medullary ropes, each arising first by medullary fibres from the outside of the lower part of the corpora striata,

ta, between the anterior and middle lobe, on each side of the cerebrum, and afterwards by another filament more internally, and by a third, which is more posterior and very long. They run under the anterior lobes of the cerebrum, being lodged in two superficial grooves in the basis of these lobes, and lying immediately on the dura mater, from the clinoid apophyses to the os ethmoides.

They are first of all considerably incurvated from without inwards or toward each other, and having reached near the back-side of the os ethmoides, they run for a small space parallel to and at some distance from each other. Backward they are very thin; but they gradually increase in bulk in their course, forward, toward each side of the crista of the ethmoidal bone, where they terminate in elongated papillæ, the substance of which appears to be softer than that of the nerves, and possessing more of the cinericeous substance, as Dr Sœmmering hath best described in his book, *De Bas. Enceph. Orig. et Nervor.* To which the reader is referred for a full account of the parts the author treats of.

These papillæ lie on the two sides of the lamina cribrosa, and send down a nervous filament into each hole of that lamina. At the same place, the dura mater sends off the same number of vaginæ which invest and accompany the nervous filaments and their ramifications on the internal parts of the nose.

We have already related the origin of the second pair, or optic nerves, from the eminences called *thalami nervorum optidorum*; and we have described their great curvature, and traced them all the way to their re-union, which happens immediately before the superior part of the glandula pituitaria, and consequently before the beak or production of the infundibulum. The internal carotids run upon the outsides of these nerves, immediately after their union, and before they pass through the foramina optica.

Besides their origin from the optic thalami, these
nerves

nerves have likewise a kind of communication with the tubercula quadrigemina anteriora by very fine filaments; one extremity of which is lost in the tubercles, the other in the roots of the great arches or bodies of the optic nerves. They are also connected with the crura cerebri. The internal structure of these nerves seems to change at their entrance into the optic holes, as we shall see in another place.

The union of these nerves, by the small curvatures of their cornua, is very difficult to be unfolded in human bodies. This union is commonly found to be very close: but, in some subjects, it seems to be no more than a strong adhesion; in others, to be partly made by an interfection or crossing of fibres. They have been found quite separate; and in other subjects one of them has been observed to be very much altered both in size and colour through its whole passage, the other remaining in its natural state.

The third pair, called *nervi motores, oculi communes, oculares communes*, and *oculo-musculares*, arise from the crura cerebri, between the corpora albicantia and a sulcus that separates the crura from the tuber annulare, by numerous threads collected into two bundles, the one a little longer than the other. These soon unite into their respective trunks, which pierce the dura mater behind the lateral parts of the posterior apophysis of the sella turcica, and pass afterwards along the sinus cavernosi, by the side of the carotid artery, and all the way to the broad portion of the superior orbital fissure, where they are divided in the manner to be afterwards described.

The fourth pair, called *nervi trochleares, musculares obliqui superiores*, and most commonly *pathetici*, are very small and tender, and, in proportion, very long. They arise each behind the testes by one, and sometimes by two small threads. From thence they take their course forward all the way to the edge of the anterior extre-

mities of the tentorium, a little to the outer side of the posterior clinoid process, where on each side they enter the duplicature of the dura mater, and advancing by the side of the sinus cavernosi, they accompany the third pair to the superior orbital fissure.

The fifth pair, called *nervi innominati*, or *trigemini*, are at first large trunks arising by two fasciculi from the outer and fore part of the crura cerebelli, where they join the tuber annulare a little before the seventh pair. They run down obliquely forward on the extremity of the upper or anterior side of the apophysis petrosa, very near the side of the sella sphenoidalis, where they enter the duplicature of the dura mater and sinus cavernous.

At their entry into the sinus, they form a kind of flat irregular ganglion, from which some filaments are sent off to the dura mater; and immediately afterward, each of them is divided into three great branches, one superior or anterior, one middle, and one inferior or posterior. The first branch, which may be termed *ocularis* or *ophthalmicus*, accompanies the nerves of the third and fourth pairs through the foramen lacerum of the sphenoid bone. The second, called *maxillaris superior*, goes out by the foramen rotundum; and the third, named *maxillaris inferior*, by the foramen ovale of the same bone. As the great trunk of this nerve runs down, it perforates the membrana arachnoides, which at this place forms a kind of ceiling.

The sixth pair, named *motores oculorum externi*, *oculares* or *ophthalmici externi*, and *oculo musculares externi*, are small nerves, but still not so small as the fourth pair; and they have sometimes been found double. They arise from a sulcus between the back-part of the tuber annulare and beginning of the medulla oblongata, and passing immediately under the tuber, they pierce the dura mater behind the occipital symphysis of the sphenoidal bone,

They

They run on each side in the duplicature of the dura mater to the cavernous sinus; and having entered that sinus, each of them crosses the out-side of the internal carotid artery in their way to the foramen lacerum. In this course they communicate with the first branch of the fifth pair, and by a filament or two, with the great sympathetic nerve at the side of the artery.

The seventh pair, named *auditorii*, are each divided into two portions; one from its hardness, when compared with the other parts, is called *portio dura*, or *sympatheticus minor*. This arises from the space where the crus cerebelli joins the tuber annulare. The other part is larger and softer than the former, and is called *portio mollis*, or the true *auditory nerve*. It arises from the inner surface of the fourth ventricle, and is afterwards joined by an intermediate portion described by Dr Wrisberg. The *portio mollis* is hollowed out to receive the portic dura, which accompanies it to the foramen auditorium internum.

The eighth pair, arise from the posterior extremities of the large branches or crura of the medulla oblongata, a little to the outer side of the corpora olivaria, by numerous filaments, which are collected into two bundles, one called *glossopharyngeus*, the other *par vagum*, or *sympatheticus medius*. This runs toward the foramen lacerum, which gives passage to the lateral sinus, where it pierces the dura mater, and goes out through the anterior part of that hole, having been first joined by a nervous portion that runs up from the medulla spinalis through the great occipital foramen by the name of *nervus accessorius octavi paris*, or *nervus spinalis*. This additional nerve goes out with that of the eighth pair through the foramen lacerum, lying behind it, but distinguished from it by a membranous septum.

The ninth pair, called *nervi hypoglossi externi*, *hypoglossi majores*, and commonly *gustatorii*, arise each from

the furrow which separates the corpora olivaria and pyramidalia. These branches soon unite into a trunk which passes through the anterior condyloide hole, and sometimes the branches form two trunks, which, after piercing the dura mater, unite and go through the hole above mentioned.

The tenth pair, called *nervi sub-occipitales*, arise from the medulla oblongata, under the ninth pair, chiefly from the anterior and a little from the lateral part of the extremity of the medulla oblongata, opposite to the posterior part of the condyloide apophysis of the occipital bone, by a single plane or fasciculus of small filaments which pierce the dura mater directly from within outward, at the same place where the vertebral arteries perforate it from without inwards. Frequently one or two threads come from the back part of the medulla, and are at first separated from the anterior bundle by the nervus accessorius and ligamentum denticulatum; but afterwards unite with it into one trunk.

Nerves of the medulla spinalis. The nerves formed by the lateral union of the anterior and posterior filaments of the medulla spinalis, go out of the bony canal of the spina dorsii, toward each side, through the intervertebral holes, through the anterior holes of the os sacrum, and the lateral notches of the os coccygis; and from thence they have the general name of *nervi vertebrales*. They are divided in the same manner as the vertebræ, into seven pair of cervical nerves, twelve pair of dorsal, five pair of lumbar, and five pair of nervi sacri.

As the spinal marrow which furnishes all these nerves seldom goes lower than the first or second vertebra of the loins, the situation of the fasciculi of nervous filaments must be different from that of the holes through which they pass; and several of these fasciculi, both anterior and posterior, must be longer than the rest.

This

This we find from experience to be the case in the following manner.

The fasciculi of nervous filaments of the medulla spinalis, which produce the cervical nerves, run more or less transversely toward each side from their origin to their passage through the intervertebral holes. The fasciculi which form the dorsal nerves run a little obliquely downward from their origin to the intervertebral holes; and those which form the lumbar nerves run down more and more longitudinally from the medulla to the holes by which they go out.

Therefore the cervical fasciculi are very short in the spinal canal; the dorsal fasciculi are longer, and the fasciculi from the loins and os sacrum very long. It must likewise be observed, that the fasciculi of the four lowest pairs of the cervical nerves, and first pair of the dorsal nerves, are broader and more compounded than the following, because the brachial nerves are a continuation of these. The filaments belonging to the lumbar nerves, and those of the os sacrum, are likewise very broad, and made up of numerous filaments, as being the roots of the large nerves which go to the lower extremities. The dorsal filaments are very small.

The cervical and lumbar fasciculi are not only broader and made up of more filaments than the dorsal, but also situated much closer to each other, the lumbar fasciculi being still more so than the cervical; whereas in the dorsal, a considerable interstice is left between the fasciculi.

These lumbar fasciculi, from their origin to the extremity of the os sacrum, form, through the whole canal of the lumbar vertebræ and of the os sacrum, a large bundle of nervous ropes, called by anatomists *cauda equina*, because of some resemblance which it bears to a horse's tail, especially when taken out of the canal, and extended in clear water.

Though the medulla spinalis ends at the first vertebra of the loins, the vagina of the dura mater by which it

is

is invested, is continued through the rest of the bony canal all the way to the extremity of the os sacrum, and involves the great bundle or cauda equina, the cords of which pierce it on each side nearly opposite to the places where they pass through the intervertebral holes, and the anterior holes of the os sacrum, almost in the same manner as was said above in describing the general formation of the vertebral nerves.

This vagina of the dura mater being separated from the canal of the vertebræ, and the lateral elongations which serve for particular vaginæ to the cords being cut off, it presently shrinks up and contracts in the same manner as all the other elastic parts of the human body; for instance, as an artery does when cut transversely soon after death. Therefore its true length must be taken while it is *in situ*, and likewise the true situation of the lateral elongations.

From all this a conclusion may be drawn of great importance, not only in anatomical and philosophical inquiries, but also for understanding local diseases, wounds, &c. which is, that when we have occasion to consider any particular nerves near the vertebræ of the back or loins, or near the os sacrum, we must remember, that in the spina dorſi, the origin of these nerves is not even with their passage out of the spine, but proportionably higher. If, for instance, we inquire about any of the lowest nervi sacri near the os coccygis, we must not stop at the extremity of the os sacrum, but trace its origin as high as the last vertebra of the back, or first of the loins.

The membrana arachnoides accompanies the original fasciculi separately, to their passage through the lateral elongations of the dura mater, forming a kind of duplicature, breaks, or discontinuations, between the cords which run in the vagina of the dura mater. The pia mater adheres very closely both to the fasciculi and filaments of which they are composed.

Among the original productions of the nerves of the
medulla

medulla spinalis, we ought still to reckon the formation of the nervi accessorii of the eighth pair. They arise from the lateral parts of this medulla by several filaments, about the third or fourth vertebræ of the neck, and sometimes lower. They run up on each side between the anterior and posterior ranks of the nervous fasciculi, increasing gradually in size by the accession of new filaments from the posterior fasciculi.

Having reached above the first vertebra of the neck, they have a kind of adhesion or communication with the neighbouring ganglions of the nervi sub-occipitales, or those of the tenth pair. Above this adhesion they receive two filaments each, from the back-side of the medulla, and afterwards continue their course towards the great occipital foramen. As they enter the cranium, they communicate with the nerves of the ninth and tenth pairs; and afterwards they join those of the eighth pair, with which they return out of the cranium.

§ 8. *Blood-vessels of the brain and medulla spinalis.*

Arteries. THE arteries which supply the cerebrum, cerebellum, and medulla oblongata, come partly from the carotids which enter the cranium through the canals in the apophyses petrosæ of the ossa temporum, and partly from the vertebrales which enter by the great occipital foramen, and send off the arteriæ spinales into the canal of the spine for the medulla lodged there.

All these arteries are divided into several branches, which send out a great number of ramifications distributed through both substances of the brain, and thro' the whole extent of the pia mater. The dura mater, both of the cerebrum and cerebellum, has arteries peculiar to it, which have been already described.

The internal carotid on each side enters the cranium by the great canalis petrosus, in an angular or winding course, as was observed in the description of the skeleton. The inner surface of this canal is lined by a production

duction common to the dura mater and inferior pericranium; to which the artery adheres only by a loose filamentary substance, in which the plexiform filaments run that belong to the great sympathetic nerve.

Having passed through the bony canal, it immediately bends upward toward a notch in the sphenoidal bone, and through that notch it enters the cranium. Immediately after this, it penetrates the cavernous sinus on the side of the sella turcica; where having formed a third curvature, it goes out from it, from below, upwards; and is bent a fourth time round the anterior clinoid apophysis, from before backward. By this course it is in a manner bathed in the blood of the cavernous sinus, together with the sixth pair of nerves.

After this fourth curvature, the internal carotid having now reached the side of the infundibulum, and consequently being very near its fellow, these two arteries communicate sometimes by a very short transverse arterial production. At this place each of them, after sending a branch through the foramen opticum to the eye, divides into two principal branches, one anterior, the other posterior; and sometimes into three, in which case there is a middle branch between the two former.

The anterior branch runs, first of all, forward under the basis of the cerebrum, separating a little from the same branch of the other carotid. They approach each other again under the interstice between the two olfactory nerves, communicating by a very short anastomosis, and sending small twigs to that pair of nerves. They afterwards separate, being each divided into two or three rami.

The first ramus of the anterior branch goes to the anterior lobe of the cerebrum. The second, which is sometimes double, is inverted on the corpus callosum, to which it gives ramifications, as also to the falx of the dura mater and middle lobe of the cerebrum. The third, which is sometimes a distinct branch, sometimes only

only an additional ramus to the second, goes to the posterior lobe of the cerebrum. This third ramus is sometimes so considerable as to deserve to be reckoned the middle branch of the three principal ones.

The posterior branch communicates first of all with the vertebral artery of the same side, and then is divided into several rami on the superficial circumvolutions of the cerebrum, and between these circumvolutions all the way to their bottom. The anterior and middle branches, when there are three, distribute the same kind of ramifications to the circumvolutions, and to their interstices.

All these different ramifications run on the duplicature of the pia mater, from which they receive a kind of additional coats; and the capillaries being distributed upon it in a reticular manner, do afterwards penetrate the cortical and medullary substance; in which last they terminate insensibly.

The vertebral arteries enter through the great occipital foramen, having first pierced on each side the elongations of the dura mater at the same place where the sub-occipital nerves, or those of the tenth pair, pierce it as they go out; the arteries in this place lying above the nerves.

At their entry into the cranium they send each several ramifications to the cauda of the medulla oblongata, and to the corpora olivaria and pyramidalia: which ramifications are distributed on the sides of the fourth ventricle; produce the plexus choroides; are spread on the whole surface of the cerebellum; insinuate themselves between the strata, always invested by the duplicature of the pia mater; and are at length lost in both substances of the cerebellum.

Afterwards the two vertebral arteries turn toward each other, for the most part immediately under the posterior edge of the great transverse or semi-annular protuberance of the medulla oblongata, where they unite and form one common trunk. This trunk passes
directly

directly from behind forward, under the middle of the great protuberance, and partly in the middle groove of the convex surface of that protuberance, at the anterior edge of which it terminates.

In its passage through the groove, this trunk sends off several small branches on each side, which surround transversely the lateral portions of the protuberance, being partly lodged in the small lateral grooves of these portions. These lateral branches are afterwards distributed to the neighbouring parts of the cerebrum, cerebellum, and medulla oblongata.

This common or middle trunk of the vertebral arteries having reached the edge of the great protuberance, is divided again into small branches; each of which soon communicates with the trunk of the internal carotid on the same side. Instead of this bifurcation, the two last or most anterior lateral branches send each sometimes a small branch forward, which form the anastomoses with the internal carotids.

The principal arteries of the medulla spinalis, called commonly *arteriæ spinales*, are two in number, one anterior and one posterior, lodged in the grooves by which the medulla is divided into lateral portions on both sides. They arise from the vertebral arteries, a little above the great occipital foramen, where these arteries send each a small ramus downward, as soon as they enter the cranium; and having got under the extremity of the medulla oblongata, they send off two other branches backward.

The first two branches uniting soon after their origin, form the *arteria spinalis anterior*, which runs down within the canal of the vertebræ along the anterior groove of the medulla. The other two small branches are inverted on the sides of the medulla oblongata, and from thence running backward, they unite much in the same manner with the first two, and form the *arteria spinalis posterior*, which runs down along the posterior groove of the medulla spinalis.

The two spinal arteries, in their course downward along the medulla, send off on each side lateral ramifications, by which they frequently communicate with each other, and with the vertebral, intercostal, lumbar, and sacral arteries; and sometimes they are in a manner split for a little way, and then unite again.

The veins of the cerebrum and cerebellum, &c. may in general be looked upon as not only forming the longitudinal sinus of the dura mater, and the two great lateral sinuses, but also all the inferior sinuses of that membrane; in all which sinuses the veins terminate by different trunks, in the manner already said in the description of the great superior sinus. Their principal ramifications accompany all the cortical circumvolutions of the cerebrum, and directions of the strata of the cerebellum, running always in the duplicature of the pia mater. The veins of the plexus choroides, in general, are of the number of those already mentioned.

The veins of the medulla spinalis terminate partly in the superior extremities of the two vertebral veins, partly in the two venal ropes termed *sinus venosi*, which run down laterally on the convex side of the production of the dura mater, and form at different distances reciprocal communications, by semiannular arches, as by so many subordinate sinuses. The two longitudinal sinuses communicate likewise in their passage with the vertebral veins, in the same manner as the neighbouring arteries.

From the foregoing history of the arteries belonging to the brain, it appears, that a very great quantity of blood is in every pulsation sent to this organ, inasmuch that, according to Dr Haller, it makes above a sixth part; or rather, from Dr Monro's calculation, a tenth part of the whole blood that goes throughout the body, and derived from trunks that are very near the heart, springing from the convexity of the aorta. From hence it is probable, that the strongest parts of the
blood

blood go to the head, and such as are most retentive of motion. Is not this evident from the effects of mercurials exerting themselves almost in the head only; from the sudden force and action of inebriating spirits upon the head; from the short stupor which camphor excites; from the heat, redness, and sweat, which happen oftener in the face than other parts of the body; to which add, the more easy eruption of volatile and contagious pustules in the face? Dr Wrisberg, however, observes, that all these arguments are not of the same force: for mercury, applied in different ways to the body, produces its effect not in the head alone; since it occasions in some a diaphoresis, in others a diarrhoea, and in others it acts as a diuretic. The well guarded passage of these great and important vessels in their ascent to the head, defends them from any great injury. The frequent inosculations of one trunk, with the other going to the head, as well as the frequent communications of their branches among themselves, lessen any danger that might ensue from obstruction. Hence, when the carotids are tied, the animal neither dies nor seems to be very uneasy. The considerable flexures of the vertebral and carotid artery serve to moderate the impulse of the blood coming to the brain, since a great part of the velocity, which the blood receives from the heart, is spent by the various inflections. To which add, that some authors do not improperly observe that the arteries here grow larger or somewhat wider.

With respect to the brain, we observe it providently surrounded on all sides, first by a sphere of bones, consisting of many distinct portions; by which means it is rendered extensible, at the same time that it is effectually guarded against external pressure. To the internal surface of this bony sphere, on all sides, grows the dura mater, which is firmly attached by an infinite number of small vessels, as by so many foot-stalks to the whole surface of the said bones,

so as to be nowhere easily separable in a healthy person; this being very thin and smooth, adheres less firmly to the bones, but more strongly to the *futures*. In younger subjects, the adhesion of the dura mater to the skull is such, that the separation of it pulls off the fibres of the bones to which it is connected. In adults, many of the vessels being effaced, renders it more easily separable: yet it is not without some force, even in those, that the dura mater can be separated from the skull. From the rupture of these vessels, which enter the bones of the skull, appear those bloody drops which are observable after removing the cranium. Hence appears the vanity of all that has been advanced concerning the motion of the dura mater. As to the motion which is remarked by the writers of observations upon wounds in this part; that, being preternatural, was the consequence of the beating of the arteries (in a part where the resistance of the bone was now removed, while the rest of the dura mater next to the skull sustained the force of the heart without motion); or of the brain swelling during expiration. Also that part, says Dr Haller, which is properly the dura mater, viz. the inner portion, has neither nerves nor sensation, nor irritability, while the outer part is supplied with small nerves and blood-vessels coming through all the holes of the skull. (Later physiologists observe in general, that the dura mater has but few nerves, and but little sensibility in the sound state; but that surgical phenomena show it is not totally destitute of sensibility.)

The internal part of the dura mater having left the external part adhering firmly to the bones of the skull, runs inwards to form the processes which serve to prevent the parts from pressing one another in all situations and postures of the body; and they likewise hinder one part of the brain from bruising the other by any shock or concussion. Hence it is, that in the more active quadrupeds, where a concussion is more likely to happen, the brain and cerebellum is divided by a bony partition.

With respect to the glands of Pacchioni placed near the falx, their use is not yet sufficiently known. But the vapour, which exhales from the surface of the pia mater, is not separated by these glands, for it is every where exhaled, even into the ventricles, where there are none of them; and it plentifully transpires every where from the mouths of the least arteries, as we see by experience, when water or fish-glue are injected, which sweat out through every point in the surface of the dura mater.

The next covering of the brain, which is more close to it, and presses the whole surface of the brain, as that does the cavity of the skull, is the arachnoides. This very thin or tender membrane, being pellucid like water, every way surrounds the brain, whose inequalities it climbs over, and according to its extreme thinness is pretty strong, and surrounds the larger vessels in such a manner, that the said vessels seem to run between the pia mater and arachnoides.

The third or innermost covering of the brain, which is soft and cellular, is properly the *pia mater*. This immediately invests the whole surface of the brain and spinal marrow on all sides, is tender, and made up of a vast number of small vessels which it conveys into the substance of the brain.

The *veins* of the brain are not disposed in the same manner with those in other parts of the body. For neither have they any valves, nor do they run together in company with the arteries, nor have their trunks the structure which is commonly observed in the other veins. The veins from the different parts of the brain run into the sinuses which have been already described.

The great quantity of blood which goes to the brain, the greater impulse with which it is sent into the carotid arteries, and the security of this part from every kind of pressure by a strong bony fence, joined with the slower motion of the blood through the abdominal viscera and lower extremities, also the perpetual exercise

cise of the brain and senses, do all determine a copious flux of blood to these parts, and some other causes serve to fill the head surprisngly with blood. Hence it is that a redness of the face, a turgescence and sparkling of the eyes, with a pain and pulsation or throbbing of the arteries in the head, are so frequently followed with a bleeding at the nose, by violent exercises or motions of the body. From hence, therefore, it is evident, that if the veins were of a thin and round structure in the brain, they would be unavoidably in greater danger of rupturing, and consequently apoplexies (to which, in their present state, they are often liable) would be much more frequent. To avoid this, therefore, nature has given a different figure to the veins which carry out the blood from the brain, by which they are more easily and largely dilatable, because they make an unequal resistance: their texture is likewise very firm, and more difficultly ruptured, especially in the larger sinuses, which perform the office of trunks; for as to the sinuses of the lesser sort, they are either round, half cylindrical, or of an irregular figure. Besides this, nature has guarded the sinuses by cross-beams internally, made of strong membranes, and detached from the right to the left side at the bottom of the sinus, which in greater distensions they draw towards a more acute angle, which is capable of a larger dilatation, strengthening and guarding it from a rupture at the same time. She has likewise, in these veins, provided numberless anastomoses, by which they open mutually one into another, and openly communicate with the external vessels of the head and with those of the spinal medulla, by which means they are capable of freeing themselves more easily whenever they are overcharged with blood.

It is by some queried, Whether a part of the arterial blood is not poured into the sinuses of the brain; and whether they have not a pulsation excited from that blood? That they have no pulsation, says Dr Haller,

is past doubt; because the dura mater every way adheres firmly to the skull, but much more firmly in those parts which are the seats of the sinuses. But Dr Monro observes, that whilst the heart is performing its systole, the arteries here, as elsewhere, may be dilating; and in the mean time, a quantity of blood equal to that which is dilating them, is passing out of the head by the veins. *See Obs. on the Nervous System.* Indeed the sinuses receive liquors injected by the arteries; but whether those transude through the small exhaling arterial vessels, or whether they first make a complete circle through the veins, as indeed is much more probable, we are not yet furnished with experiments enough to determine.

Thus all the blood of the brain is finally conveyed into the jugular veins, which are very dilatable, and for that reason guarded with valves to prevent a return of the venous blood from the right auricle, being at the same time surrounded with a good deal of cellular substance. As to the blood which goes from the head to the vertebral veins, it is a very inconsiderable quantity; but the jugulars answer in such a manner to the great upper vena cava in a direct course, that they afford the highway for the blood to return back to the heart. The branches of these are commonly the same with those of the brain; namely, the veins of the brain, and those of the face.

The veins form innumerable anastomoses with one another, that the blood may return with the greatest ease from the head, of which the repletion is very dangerous. The brain is also more easily evacuated in the time of inspiration, and subsides as we see when the skull is opened, but swells during the time of expiration. Hence, blowing the nose, sneezing, and coughing, are dangerous to those whose brain is swelled by retained blood.

Whether or not there are lymphatic vessels to be seen in the brain, is by some questioned. Dr Haller thought it probable that there are no lymphatic vessels

sels in the brain; because no conglobate glands are found there, and that the superfluous moisture is absorbed by the red veins. But according to most of the present physiologists, lymphatic vessels take up the superfluous fluids of the brain, as well as of the other parts of the body, although they cannot be distinctly shown.

"In almost no viscus," says Dr Wrisberg, "has the existence of lymphatic vessels been oftener asserted and again denied, than in the brain. Although, indeed, I am fully certain, that a group of lymphatic glands is nowhere found without lymphatic vessels, by no means, however, could I assert, that there are nowhere lymphatic vessels where glands do not appear. By analogy drawn from the whole body and all the viscera, I am led to think, that the brain is not destitute of its aqueous vessels, and that they run in particular upon the surface, not in the heart of its substance, although I myself have never seen any, but those moving on the choroid plexus towards the tentorium, and on the inner surface of the dura mater, in the course of the superior longitudinal sinus. But I cannot discredit the industry of the celebrated Sommering, who confirms the observations of King, Collins, and Pacchioni, who saw them going upon the pia mater. I would ask, May they be joined with the glands of Pacchioni? May these corpuscles supply the place of lymphatic glands?"

It now remains for us to speak of the encephalon itself. Upon the surface of the brain lies the cortex, the fabric of which has been a long time controverted; but it is now sufficiently evident, from anatomical injections, that much the greater part of it consists of mere vessels, which are every way inserted from the small branches of the pia mater, detached like little roots into the cortical substance, and conveying a juice much thinner than blood in their natural state, although in some diseases, and by strangling, they often receive even the red parts of the blood, more especially in brutes and birds. The remaining part of the cortex, which is not filled by any injection, is probably either

an assemblage of veins, or of yet more tender vessels ; for no other dissimilar parts are apparent in the cortex, whilst it is in an entire or natural state ; from whence one may conjecture some part of it to be tubular, and the other part solid. As to glandules making the fabric of the brain, that notion has been discarded by universal consent ; nor indeed has there been any other opinion received with less probability than this.

In order to gain a knowledge of the nature of medulla, which lies under the cortex, we are to consider the anatomical structure of this part of the human brain, compared with the brains of brute animals and fish. Therefore this part of the brain, which follows immediately under the outer gyri or convolutions of the cortex, is of a white colour, and becomes gradually broader and more abundant ; so that, at length, it makes up the whole oval section of the brain, except only the gyri in the surface, which makes the cortex, as was mentioned in the former part of this section.

The nerves of the brain, as well as of the spinal marrow, divide into branches like the blood-vessels, but in acute angles, and often in a course manifestly retrograde, growing gradually softer and less in bulk, though sometimes they become thicker as they recede from the brain, till at length their ultimate extremities, which are seldom visible, seem to terminate in a pulp, by depositing the firm integuments with which they were covered, after the manner which we observe in the optic nerve. But the rectilineal course of the fibres, continued from the brain itself, is such, that it is never broken off by the division or splitting of a nerve into smaller threads, which only recede from each other by an opening of the cellular substance that tied them together. This appears from the disorders, which are determined not to all, but only to some single parts by injuries of the brain ; as a loss of the voice, deafness, dumbness, and palsies of particular muscles. They are connected in their course by the cellular substance to
the

adjacent parts, but have hardly any elasticity; whence they do not fly back after being divided, but only expel, by the contraction of their integuments, the soft medulla which they include. But though they are irritated ever so much, they are neither contracted, nor are they rendered shorter during the motion of the muscles which they produce. A great many nerves, says Haller, are sent into the muscles; many of them go to the skin; but fewer to the viscera, and fewest of all to the lungs. Wrisberg, however, observes, that more nerves manifestly enter the organs of sense than the muscles; and that the lungs are supplied with more nerves than the spleen, uterus, and other viscera. Haller also asserts, that none at all go to the dura and pia mater, arachnoides, tendons, capsules, and ligaments, and lastly the whole secondary membranes. That these parts have few nerves is certain; but that nerves can be traced into some of them, as the ligaments, cannot now be denied. *See* *Monro and Walter's Tables*. They make frequent inosculations with each other, or one trunk gives off many branches: and principally from the conjunction of these branches the nervous ganglia are formed; i. e. hard nervous tumours, for the most part replenished with blood-vessels, and included in a firm membrane. These Dr Monro considers as sources of nervous matter and energy; for they are full of nervous fibrillæ, intermixed with a yellowish or reddish brown substance, something similar to the cortical substance of the brain. *See* *Obs. on the Nervous System*.

Thus far we are taught by anatomy concerning the brain and nerves; it now remains only that we explain the physiological uses of these parts. Every nerve, therefore, that is irritated by any cause, produces a sharp sense of pain. But we must reckon the mind to be changed, when any change happens to the body. It is the medullary part of the nerve which feels the pain. If the nerve was endued with any peculiar sense, that sense perishes when the nerve is compressed or dis-

fectcd: the senses of the whole body are lost by a compression of the brain; and of those parts whose nerves originate below the seat of pressure, if you compress the spinal marrow. If certain parts of the brain are compressed from which particular nerves arise, then those senses only are lost which depend on the nerves, as the sight or hearing. Those parts of the body which receive many nerves, as the eyes and penis, have the most acute sensation; those have less sensibility which receive few nerves, as the viscera; and those which have fewest nerves, as the dura mater, tendons, ligaments, secundines, bones, and cartilages, have little or no sensation in the sound state.

It is therefore evident, that all sensation arises from the impression of an active substance on some nerve of the human body; and that the same is then represented to the mind by means of that nerve's connection with the brain. But this seems to be false, that the mind perceives immediately by means of the sensoria and branches of the nerves. For this opinion is refuted, by the pains felt after amputation, the cessation of all pain when the nerve is compressed, and the destruction of the senses by diseases of the brain. And that the effect of the senses is preserved in the brain, is evident from the loss of memory which follows when the brain is injured or compressed; also from the delirium which happens in some diseases, and the stupor and sleepiness which happen in others.

Another office of the nerves is to excite motions, even the most violent ones in the muscles. When a nerve is irritated, the muscle to which it goes is immediately convulsed; or if it sends branches to several muscles, they are all convulsed at the same time. This happens during the life of the animal, and a little after its death, while all the parts are moist. By a great irritation other muscles are thrown into convulsions, and afterwards the whole body. Nor is it necessary that the nerve should be whole; for even when it is cut,
an

an irritation of it will excite similar motions in the muscles. On the other hand, when a nerve is compressed or tied, a palsy follows; for the muscles which have their nerves from that one lie unmoved, when they are commanded by the will to act. They also recover their motion when the compression is removed, provided the nerve has received no hurt.

But the medulla of the brain being vellicated or irritated deeply in its crura, dreadful convulsions ensue throughout the whole; and this without any exception, whatever be the part of the brain so affected; nor is there any difference in the brain, cerebellum, or corpus callosum. The same consequences also follow, if the spinal medulla be irritated. But if the encephalon itself be compressed in any part whatever, there follows thence a loss of sense and motion in some part of the body, which must be the part whose nerves are detached from the affected or compressed quarter of the brain. This is clearly evidenced from experiments which have been made on particular parts of the brain disordered: as from those, for instance, in which the origin of the nerves is compressed, the voice is lost; or the motion of one arm or leg, or one side of the pharynx, is abolished. But in the injuries of the spinal medulla, it is still more evident, that those parts which receive their nerves arising from the place injured in the medulla, are either convulsed, if that be irritated, or rendered paralytic, if it be compressed. But when any more considerable or large portion of the brain suffers a compressure, either from blood, water, scirrhus, an impacted bone, or other mechanical causes, the greatest part, and then the whole, of the body loses its power of motion; of those organs which obey the will when the malady is in a lesser degree, and of them all when it is greater; all which disorders cease upon removing the compressing cause. Lastly, if the spinal medulla, entering the neck, be injured, death immediately follows, probably from the intimate connection
between

between the nerves of this place and those that supply the vital parts.

These things being considered, there seems to be no doubt, but the cause of all motion in the human body arises from the brain with its annexed cerebellum and spinal marrow; and that it thence proceeds through the nerves to all the muscular parts of the body. The cause, therefore, of this motion cannot reside in the parts themselves, because otherwise the moving cause would continue to act after being separated from the brain; nor would it be increased by irritating the brain, or weakened by a compressure of it.

Whether or not is there in the brain any principal part, in which resides the origin of all motion, the end of all the sensations, and where the soul has its seat? Whether is this proved by the frequent observation, that the senses are sometimes entire, and that motion likewise remains, though the brain is grievously hurt? Is it in the corpus callosum? Or is this shown by the greater fatality of wounds or diseases in the corpus callosum? Is this body sufficiently connected with the nerves? Are there any experiments which deduce from thence the fifth, seventh, and other nerves? Doth not the same or even greater mortality of wounds in the medulla spinalis prove the same thing? Yet this is not the seat of the soul, seeing, though it is compressed or even destroyed, the person will survive a long time with the perfect use of all his senses. Nay, this opinion is opposed by very many facts: birds have no corpus callosum; and wounds in that body are not in the least more mortal than those in other parts of the brain, as appears from undoubted experiments.

But the power of the cerebellum is not greater in exciting the vital motions, nor are the vital and animal functions distinct; nor does the cerebellum produce the nerves of the heart and of other vital organs, and the brain those which go to the organs of sense and voluntary motion. From the cerebellum the fifth nerve
is

is most evidently produced ; but that goes to the tongue, pterygoide, buccinator, temporal, and frontal muscles, the lap of the ear, the eye, the nostrils ; all which are parts either moved by the will, or destined for sense. Again, the same nerve, like the eighth, sends vital branches to the heart and lungs, animal and voluntary ones to the larynx, and sensitive ones to the stomach. Again, it is not even true, that disorders of the cerebellum bring on so certain and speedy death. For certain experiments, even of our own making, show that it has borne wounds and scirrhi, without taking away life ; nor is it much different from the brain, only that it is softer and more tender ; and lastly, we have known, and that not very rarely, wounds of the cerebellum cured. The power, however, of this part, in exciting convulsions, is somewhat greater.

Concerning the seat of the soul, we must inquire experimentally. In the first place, it must be in the head, and not in the spinal marrow. For though this is obstructed, the constancy of the mind remains the same. Again, it appears, from the experiment of convulsions arising, when the inmost parts of the brain are irritated, that it lies not in the cortex, but in the medulla ; and, by a probable conjecture, in the crura of the medulla, the corpora striata, thalami, pons, medulla oblongata, and cerebellum. And again, by another not absurd conjecture, where the origin of every nerve lies, as the first origins of all the nerves taken together make up the sensorium commune. Are the sensations of the mind represented there, or do the voluntary and necessary motions arise in that place ? This seems very probable. For it does not seem possible, that the origin of motion can lie below that of the nerve ; for although it should be assumed gratis, that some part of the nerve is immoveable, or insensible, yet that is altogether similar to the remainder of the nerve. Nor can the origin of motion depend upon the arteries, which have neither the faculty of sensation nor that of voluntary motion.

motion. It therefore follows, that the seat of the mind must be where the nerve first begins its formation or origin.

We come now to explain the manner in which the nerves become the organs of sense or motion; which, as it lies hid in the ultimate elementary fabric of the medullary fibres, seems to be placed above the reach both of sense and reason; but we shall, notwithstanding, endeavour to make this as plain as experiments will enable us. And first, it is demonstrated, that the sensation does not come through the membranes from the sentient organ to the brain, nor that motion is sent through the coverings from the brain into the muscle. For the brain itself lies deeper than these membranes, and receives the impressions of sense, and when hurt throws the muscles into convulsions. Moreover, it is certain, that the nerves arise from the medulla of the brain; the truth of which is manifest to the eye in all the nerves of the brain, more especially in the olfactory, optic, fourth and seventh pair of nerves, which continue their medullary fabric a long way before they put on the covering of the pia mater.

We must therefore next inquire into this medulla, what it is. It is a very soft substance; but its composition is fibrous, as appears from innumerable arguments; more especially to the eye in the corpus callosum, in the striatum, and thalami of the optic nerves; but still more evidently in the brains of fish, and especially in their thalami optici; but in no part of the human brain does the fibrous nature of the medulla more evidently appear than in the fornix, especially when immersed in some of the acids. Again, that the fibres of the brain are continuous with those of the nerves, so as to form one extended and open continuation, appears by observation very evidently in the seventh, fourth, and fifth pair of nerves. There is a great deal of oil in the medulla, upwards of a tenth part of its whole weight.

But

But here a controversy begins concerning the nature of this fibril, which with others of the like kind composes the substance of the medulla and of the nerves. That this is a mere solid thread, and only watered by a vapour exhaling into the cellular fabric which surrounds the nervous fibres, has been asserted by many of the moderns; but that, when it is struck by a sensible body, a vibration is excited, which is then conveyed to the brain.

But the phenomena of wounded nerves will not allow us to imagine the nervous fibres to be solid. For if an irritated nerve is shaken (and that happens after the manner of an elastic cord, which trembles when it is taken hold of), the nerve ought to be made of hard fibres, and tied by their extremities to hard bodies: they ought also to be tense; for neither soft cords, nor such as are not tense, or such as are not well fastened, are ever observed to tremulate. But all the nerves at their origin are medullary and very soft, and exceedingly far from any kind of tension: where they pass through channels, where they are well guarded, they retain the same soft texture, and are not covered with membranes, as in the intercostal nerves and the second nerves of the fifth pair: some also are soft throughout their whole length, whatever size they may be of; for example, the soft olfactory and acoustic nerves, from which we would most readily expect a tremor, as in the case of sound. Again, though the nerves are hard, they are softened in the viscera, muscles, and sensoria, before they exert their operations. Therefore, the nervous fibres cannot possibly tremulate in an elastic manner, neither at their origin, nor where they are tense. But the same, even in the proper and most favourable cases, cannot tremulate; because, through their whole length, they are firmly tied to the solid parts by means of the cellular fabric; for example, the nerves of the heart are tied to the great arteries, and to the pericardium. Finally, that the nerves are
destitute

destitute of all elasticity, is demonstrated by experiments, in which the nerves cut in two neither shorten nor draw back their divided ends to the solid parts; but are rather more elongated by their laxity, and expel their contained medulla in form of a protuberance. Again, the extreme softness of the medulla in the brain, with all the phænomena of pain and convulsion, leave no room to suspect any sort of tension concerned in the effects or operations produced by the nerves.

Add to this, that the force of an irritated nerve is never propagated upward, so as to convulse the muscles that are seated above the place of irritation. This is a consequence altogether disagreeing with elasticity; for an elastic cord propagates its tremors every way, from the point of percussion to both extremities. But if neither phænomena of sense nor motion can be explained from the nature of elasticity, the only probable supposition that remains is, that there is a liquor sent through the brain, which, descending from thence through the nerves, flows out to all the extreme parts of the body; the motion of which liquor, quickened by irritation, operates only according to the direction in which it flows through the nerve; so that convulsions cannot thereby ascend upwards, because of the resistance made by the fresh afflux of the fluid from the brain. But the same liquid being put in motion in an organ of sense, can carry that sensation upwards to the brain; seeing it is resisted by no sensitive torrent coming from the brain in a contrary direction.

It is therefore probable, that the nervous fibres, and the medullary ones of the brain, which have the same nature, are hollow. Nor is the objection which arises from the smallness of these tubes, not visible by any microscope, of any force against the proposed arguments; to which add the absence of a swelling in a tied nerve, which, in reality, is not sufficiently true; with other arguments of the like kind, which indeed show

the weakness of the senses, but have not any validity against the real existence of a juice or spirit in the nerves. If they are tubes, it is very probable that they have their humours from the arteries of the brain.

But concerning the nature of this nervous liquid, there are many doubts. Many of the moderns will have it to be extremely elastic, of an ethereal or of an electrical matter; but the more reasonable part make it to be incompressible and watery, but of a lymphatic or albuminous nature. Indeed it is not to be denied, that we have many arguments against admitting either of these opinions. An electrical matter is, indeed, very powerful, and fit for motion; but then it is not confineable within the nerves, since it penetrates throughout the whole animal to which it is communicated, exerting its force upon the flesh and fat, as well as upon the nerves. But, in a living animal, the nerves only, or such parts as have nerves running through them, are affected by irritation; and therefore, this liquid must be of a nature that will make it flow through, and be contained within the small pipes of the nerves. And a ligature on the nerve takes away sense and motion, but cannot stop the motion of a torrent of electrical matter.

A watery and albuminous nature is common to most of the juices in the human body, and may be therefore readily granted to the juice of the nerves; like the water which exhales into the ventricles of the brain from the same vessels; also, from the example of a gelatinous or lymphatic juice, which flows out in cutting through the brain in fish, and the nerves of larger animals; to which add the tumour which arises in tied nerves. But are these properties sufficient to explain the wonderful force of convulsed nerves, observable in the dissections of living animals, and even in the lesser insects, with the great strength of mad and hysterical people? Is not this difficulty somewhat lessened from the hydrostatical experiments of attraction in small tubes;

tubes; which although it may explain the strength and motion, is nevertheless inconsistent with the celerity?

The nervous liquor then, which is the instrument of sense and motion, must be exceedingly moveable, so as to carry the impressions of sense, or commands of the will, to the places of their destination, without any remarkable delay: nor can it receive its motions only from the heart. Moreover, it is very thin and invisible, and destitute of all taste and smell; yet reparable from the aliments. It is carefully to be distinguished from that visible, viscid liquor, exhaling from the vessels in the intervals between the nervous cords.

That this liquor moves through tubes rather than through a spongy solid, we are persuaded from its celerity, and the analogy of the whole body; of which all the liquids, the fat excepted, run through their proper vessels.

Therefore, upon the whole, it seems to be certain, that from the vessels of the cortex a liquor is separated into the hollow tubes of the medulla, which are continued with the small tubes of the nerves, even to their soft pulpy extremities, so as to be the cause both of sense and motion. But there will be a twofold motion in that humour; the one slow and constant, from the heart; the other not continual, but exceedingly swift, which is excited either by sense or any other cause of motion arising in the brain.

The same nerves most evidently preside over both sense and motion; as we cannot admit a distinction between the two systems of motory and sensitive nerves. If sense sometimes remain after motion is destroyed, this seems to be because much more strength is required for the latter. Dying people hear and see, when they are incapable of motion.

If it be asked, What becomes of this nervous juice, which cannot but be separated and distributed in great abundance, from so large a quantity of blood passing the brain very swiftly, in comparison of the slower moving

ving blood, from whence the milk is separated in the breast, and the urine in the lesser renal artery, or by a comparison with the mesenteric artery? it may be answered, It exhales probably through the cutaneous nerves; the lassitude, both with respect to sense and motion, which may be overcome by spirituous medicines, shows that this liquid may be both lost and repaired. Many have judged, that it also exhales into the various cavities of the body; as that of the stomach and intestines. We may expect some part of it to be reformed; that the noblest humour of the body may not be too quickly dissipated. That it nourishes the body, is incredible: It is too moveable to expect adhesion from it: that is the office of a slow and viscid humour.

But then, what is the design of so many protuberances in the brain? what are the particular uses of the ventricles, nates, and testes; with the distinction of the brain from the cerebellum; and the communication betwixt one side of the brain, cerebellum, and spinal medulla, with their opposite sides, by so many transverse bundles of fibres? Future experience alone can determine these circumstances, when the brains of several animals shall have been compared with their functions.

The ventricles seem to be made of necessary consequence, and towards the greater use and distinction of the parts. And that the corpora striata or thalami might keep their medullary parts from cohering one to another, it was necessary for a vapour to be poured betwixt them; and the same is true with regard to the brain and cerebellum. Besides the conjectures proposed by authors, Dr Monro adds, That the ventricles serve to increase the surface of the pia mater; and, that whatever purposes are served by that membrane and its vessels on the surface of the brain, we must suppose the same performed by it within the ventricles. Perhaps, likewise, the necessity of administering a degree of warmth to the close medulla of the brain may be

one reason for these cavities, by which the arteries enter, and are distributed in great numbers. Perhaps also it was proper, that, in the inmost part of the brain, small vessels only, without any large ones, should enter. We may also suspect, that the softness of the fibres of the brain requires shortness in order to sustain their own weight.

The uses of most of the protuberances we are not acquainted with, but have them yet to learn from diseases, and from anatomical experiments made on animals having a brain like that of mankind. But, in these respects, we have little hopes of success in parts that are so small, so deeply, and so difficultly situated, and hardly ever to be approached but by a wound soon fatal. Whether these parts are so many distinct provinces in which our ideas are stored up, and whether this be confirmed by the protuberant thalami of the optic nerve, are indeed questions. But then most of these protuberances send out no nerves at all.

As to the internal communication of one part with the other by striæ or ducts; that seems to conduce to the advantage of motion, and probably of sense likewise. Some of these communications join the brain with the cerebellum; others join the spinal medulla with the nerves of the brain itself, as in the accessory nerve; and most of them join the right and left parts together, as in the anterior commissure, and in the two posterior, in that of the corpus callosum, in the striæ betwixt a process of the cerebellum and testes; to which add the medullary cross-bars in the medulla oblongata and spinalis. For from this structure, it seems manifestly to follow, as well as from numberless experiments and observations, that when the right side of the brain is injured, all the nerves which, on the contrary, belong to the left side of the body, become diseased or paralytic, and the reverse. Moreover, by this contrivance, nature seems to have provided, that, in whatever part
of

of the brain any injury may happen, the nerve that arises from thence is, by this means, not always deprived of its use. For if the said nerve receives its fibres by communicating bundles, as well from the opposite as from its own hemisphere of the brain, its office may in some measure be continued entire by the fibres which it receives from the opposite side, even after those of its own side are destroyed. Accordingly, we have numberless instances of wounds, and with a considerable loss of substance from the brain, which yet have not been followed with injury to any nerve, or to any of the mental faculties. Many other less inequalities, stripes, protuberances, and nerve-like impressions, appear in the brain from mechanical necessity, with the pulsation of the vessels, and the pressure or figure of the contiguous incumbent parts.

SECT. II. *The EYE.*

§ 1. *The Eye in general.*

Situation and composition. THE eyes are commonly two in number, situated at the lower part of the forehead, one at each side of the root of the nose; and they are made up of hard and soft parts. The hard parts are the bones of the cranium and face; which form two pyramidal or conical cavities, like funnels, to which we give the name of *orbits*. The soft parts are of several kinds.

The principal and most essential soft part in each organ is the globe or ball of the eye; the others are partly external and partly internal. The external parts are the supercilia or eye-brows, the palpebræ or eye-lids, the caruncula lachrymalis, and the puncta lachrymalia; and the internal parts are the muscles, fat, lachrymal gland, nerves, and blood-vessels.

The orbits. Seven bones are concerned in the composition

position of each orbit, viz. the os frontis, os sphenoidale, os ethmoides, os maxillare, os malæ, os unguis, and os palati. In each orbit we are to consider the edge, sides, and bottom. The edge is formed by the os frontis, os maxillare, and os malæ; the bottom by the os sphenoides and os palati; and all these bones, except the os palati, contribute to form the sides. The bottom is perforated by the foramen opticum of the os sphenoides; and the external side near this foramen by two orbitary fissures, one superior, called *sphenoidalis*, the other inferior, called *spheno-maxillaris*, as has been already said in the description of the skeleton.

All the cavity of the orbit is lined by a membrane, which is an elongation or production of the dura mater; and it comes partly through the foramen opticum of the os sphenoides, and partly through the sphenoidal or superior orbitary fissure. This membrane, which may be looked upon as the periosteum of the orbit, communicates with the periosteum of the basis cranii, by the inferior orbitary fissure, and with the periosteum of the face at the edge of the orbit. At the upper part of the edge of the orbits, the two periosteum form a kind of broad ligament, and a narrow one at the lower part of this edge, which may be called *ligaments of the palpebræ*.

The particular situation of the orbits represents nearly two funnels, placed laterally at a small distance from each other, in such a manner as that their apices are almost joined, their nearest sides almost parallel, and the other sides turned obliquely backward; and for this reason the middle of the great circumference or edge of each orbit, is at a much greater distance from the septum narium, than the bottom or apex; and the edge or great circumference is very oblique, the temporal or external angle of the orbit lying more backward than the nasal or internal angle.

§ 2. *The Globe or Ball of the Eye.*

Composition. THE globe of the eye being the most essential of all the soft parts belonging to the organ of sight, and being likewise a part which we are obliged to mention as often as we speak of the other soft parts, must be first described. It is made up of several proper parts; some of which being more or less solid, represent a kind of shell formed by the union of several membranous strata called the *coats of the globe of the eye*; and the other parts being more or less fluid, and contained in particular membranous capsulæ, or in the interstices between the coats, are termed *the humours of the globe of the eye*. These capsules are likewise termed *coats*.

The coats of the globe of the eye are of three kinds. Some form chiefly the shell of the globe; some are additional, being fixed only to a part of the globe; and some are capsular, which contain the humours. The coats which form the globe of the eye are, The sclerotic, to which the convexity of the globe is owing; the cornea, which forms the anterior part of the globe; the iris, choroides, and retina. The additional coats are two; one called *tendinosa* or *albuginea*, which forms the white of the eye; and the other, *conjunctiva*. The capsular tuniæ are likewise two, the vitrea and crystallina.

The globe of the eye thus formed, receives from behind a pretty large pedicle, which is the continuation of the optic nerve. It is situated about the middle of the orbit in the manner which we shall afterwards see; and it is tied to it by the optic nerve, by six muscles, by the tunica conjunctiva, and by the palpebræ. The back-part of the globe, the optic nerve, and muscles, are surrounded by a soft fatty substance, which fills the rest of the bottom of the orbit.

The humours are three in number; the aqueous, vi-

treous, and crystalline. The first may properly enough be called an *humour*, and is contained in a space formed in the interstices of the anterior portion of the coats. The second or vitreous humour is contained in a particular membranous capsula, and fills above three-fourths of the shell or cavity of the globe of the eye. It has been named *vitreous*, from its supposed resemblance to melted glass; but it is really more like the white of a new-laid egg.

The crystalline humour is so called from its resemblance to crystal, and is often named simply the *crystalline*. It is rather a gummy mass than an humour, of a lenticular form, more convex on the back than on the fore side, and contained in a fine membrane called *membrana* or *capsula crystallina*. What has been here said is sufficient to give a general idea of the three humours of the globe of the eye.

§ 3. *The Coats of the Eye in particular.*

THE most external, the thickest, and strongest coats of the eye, are the sclerotica and cornea. They invest all the other parts of which the globe is composed.—The sclerotic is of a white colour, and made up of many fibres closely connected; and is of a firm texture, resembling parchment. About the middle of its posterior convex portion, where it sustains the optic nerve, it is in a manner perforated, and thicker than any where else, its thickness diminishing gradually toward the opposite side, and its substance is penetrated obliquely in several places by small blood-vessels and nerves. The course of the nervous filaments thro' this coat is very singular: they enter the convex side at some distance from the optic nerve; and running from thence obliquely through its substance, they pierce the concave side some way farther forward.

The cornea is made up of several strata or laminae closely united by cellular substance, and of a different

rent texture from the former ; besides, it receives no blood-vessels in the natural state. When macerated in cold water, it swells ; and then its strata may be separated from each other. If it be macerated till it begin to become putrid, and is then plunged into boiling water, it separates readily, from the sclerotic being joined only by cellular substance. (See *Traité complet d'Anatomie.*) It is likewise thicker than the sclerotic, especially in new-born children, where its posterior surface almost touches the iris.

This portion is something more convex than the sclerotica, so that it represents the segment of a small sphere added to the segment of a greater ; but this difference is not equally great in all persons. The circumference of the convex side is not circular as that of the concave side, but transversely oval : for the superior and inferior portions of the circumference terminate obliquely ; but this obliquity is more apparent in oxen and sheep than in man.

The cornea is perforated by a great number of imperceptible pores, through which a very fine fluid is continually discharged, which soon afterwards evaporates ; but we discover it evidently by pressing the eye soon after death, having first wiped it very clean ; for we then see a gradual collection of a very subtle liquor, which forms itself into little drops ; and this experiment may be several times repeated on the same subject. It is this dew that forms a kind of pellicle on the eyes of dying persons, which sometimes cracks soon after, as is observed in the *Memoirs of the Academy* for 1721.

Tunica choroides. The next coat of the globe of the eye is the choroides, which is of a blackish colour, more or less inclined to red ; and adheres, by means of a great number of small vessels, to the sclerotica, from the insertion of the optic nerve all the way to the cornea, where it leaves the circumference of the globe ; and turns inward, to form a number of little pro-

cesses termed *ciliary*, which are situated at the edge of the crystalline lens.

The external lamina of the choroides is stronger than the internal, and is of a brownish colour. At a very small distance from the cornea this lamina is most closely united to the sclerotica, by means of a whitish ring called *ciliary ligament*, or *ciliary circle*; and near the edge of the sclerotica this ring is stronger and of a different texture from what it is any where else. The choroides adheres so closely to the sclerotica, that if we blow through a small hole made therein without touching the choroides, the air will penetrate every where between the two coats, but cannot destroy this adhesion, or pass to the cornea. On the inner surface of this lamina we discover a great number of flat lines in a vortical disposition, which are the vessels named by Steno *vasa vorticosa*, or *vortices vasculosi*; of which hereafter.

The internal lamina of the choroides is thinner and of a darker colour than the external; it is formed of a black varnish, which is thicker before than behind, and is wanting at the entrance of the optic nerve. At the fore-part of the eye it lies only between the ciliary processes, leaving them white, and adheres to the vitreous humour, forming there a radiated ring. The origin of this substance has not as yet been observed; but, after a nice anatomical injection, Winslow has observed a great number of vascular stars on its inner surface. In Ruysch's works, it is termed *Membrana Ruyschiana*.

At the anterior edge of the choroides we find the iris composed of two laminæ; the posterior of which, being of the colour of a grape, was called *uvea* by the ancients. In the middle of the iris there is a hole termed *pupil*: this in a fœtus is covered with a membrane called *pupillaris*, which generally disappears about the seventh month; or between the seventh and ninth month, according to Wrisberg. Between the two laminæ of the iris we find two very thin planes of fibres, which

which have been supposed to be muscular; but this matter is not yet fully ascertained. The fibres of one plane is orbicular, and lies round the circumference of the pupil; and those of the other is radiated, one extremity of which is fixed to the orbicular plane, the other to the great edge of the iris. The iris has motions of such a nature, that the pupil is contracted at the approach of a strong light, and is dilated upon being exposed to a weak one. The different colours which appear in the iris seem to be owing to an intermixture of vessels and nerves; and that the iris possesses red vessels is evident from injection (contrary to the opinion of some physiologists), and from observations on the eye during life. (See *Monro on the Structure and Physiology of Fishes.*)

The plicæ or processus ciliares are small radiated and prominent duplicatures of the anterior edge of the choroid coat; and their circumference answers partly to that of the ciliary circle. They are oblong thin plates; their external extremities, or those next the choroides, being very fine and pointed; the internal are broad, prominent, bifurcated, and alternately long and short, making slight depressions on the fore part of the vitreous humour. In the duplicature of each ciliary fold we find a fine reticular texture of vessels; and some pretend to have seen fleshy fibres in the same place, lying in small grooves of the membrana vitrea, as we shall see hereafter.

The space between the cornea and iris contains the greatest part of the aqueous humour, and communicates by the pupilla with a very narrow space behind the iris, or between that and the crystalline. These two spaces have been termed *the two chambers of the aqueous humour*, one anterior, the other posterior, as we shall observe in describing this humour in particular.

Retina. The last coat proper to the eye is of a very different texture from that of the other two coats. It is white, soft, and tender, and, in a manner, medullary,
or

or like a kind of paste spread upon a fine reticular web, and lining the bottom of the eye, being a continuation of the optic nerve. Some authors, as Zinn, affirm, that it terminates at the ciliary circle; others, as Dr Haller, represent the whole or a part of it as extended to the lens, and even as giving a covering to that humour; but Dr Monro observes, that it ends some way behind the ciliary circle. (*See Observations on the nervous system.*) At the place which answers to the insertion of the optic nerve, we observe a small depression, in which lies a sort of medullary button, terminating in a point; and from this depression blood-vessels go out, which are ramified on all sides through the substance of the retina.

It is commonly said, that the retina is a production or expansion of the medullary substance of the optic nerve; the sclerotica, of the dura mater; and the choroides, of the pia mater, which accompanies this nerve. But this opinion is not altogether agreeable to what we observe in examining the optic nerve, and its insertion in the globe of the eye. If we take a very sharp instrument, and divide this nerve through its whole length, between where it enters the orbit and where it enters the globe, into two equal lateral parts, and then continue this section through the middle or centre of its insertion, the following phenomena will appear.

That the nerve contracts a little at its insertion into the globe; that its outer covering is a true continuation of the dura mater; that this vagina is very different from the sclerotica both in thickness and texture, the sclerotica being thicker than the vagina, and of another structure; that the vagina from the pia mater forms, through the whole medullary substance of the nerve, several very fine cellular septa; and that where it enters the globe of the eye, the pia mater does not directly answer to the choroides, and is divided into many small threads, which go through the bottom of the eye to form the retina.

The

The insertion of the optic nerve in the globe of the eye is not directly opposite to the pupilla; so that the distance between these two parts is not the same when measured on all parts of the globe. The greatest distance is on the side next the temples; and the smallest, next the nose. Winslow observes an inequality of the same kind in the breadth of the uvea, which in many subjects is less near the nose than near the temples; so that the centre of the pupilla is not the same with that of the great circumference of the iris; and he has seen the same difference in the breadth of the corona ciliaris.

§ 4. *The Humours of the Eye and their Capsulae.*

The vitreous humour. The vitreous humour is a clear and very liquid gelatinous fluid contained in a fine transparent capsula, called *tunica vitrea*, together with which it forms a mass nearly of the consistence of the white of an egg. It fills the greatest part of the globe of the eye, that is, almost all that space which answers to the extent of the retina, except a small portion behind the uvea, where it forms a fossula, in which the crystalline lens is lodged. This humour being dexterously taken out of the globe, preserves its consistence for some time in the capsula, and then runs off by little and little, till it quite disappears.

The *tunica vitrea* is described by Winslow as being composed of two laminæ very closely united, which quite surround the mass of humour; but later authors, as Sabatier, &c. find only one; which, after covering the vitreous humour, runs to the edge of the lens; and whether it goes farther, is uncertain. The anterior part of this membrane, which extends between the vitreous humour and edge of the lens, is covered with black streaks from the pigmentum nigrum, and by different authors has been called *membranula coronæ ciliaris*; by Zinn, *zonula ciliaris*. When a puncture is made
2 through

through this, and air is blown in, it forms a passage which runs round the lens, and has been termed *Canalis Pititianus*, after the discoverer, who describes it in the Memoirs of the Royal Academy 1728.

The internal surface of the tunica vitrea gives off, through the whole substance of this humour, a great number of cellular elongations or septa discovered by Riolin, so extremely fine, as not at all to be visible in the natural state, the whole mass appearing then to be uniform and equally transparent through its whole substance; but they are discovered by putting the whole, soon after it is taken out of the body, into some acedent and gently coagulating liquor. These cells must communicate with each other; for, by puncturing the membrane, and hanging up the eye for a short time, a considerable part of the humour runs out, so that the eye becomes lighter.

The radiated fulci of the tunica vitrea, which may be termed *fulci ciliares*, are perfectly black when the coat is taken out of the body. This proceeds from the black substance with which the laminæ or processus ciliares are naturally covered, as well as all the rest of the choroides, and which remains in the bottom of the fulci after the laminæ have been taken out. We observe very fine vessels in this humour, which shall be described afterwards.

The crystalline humour. The crystalline lens is a small lenticular body of a pretty firm consistence, and transparent like crystal. It is contained in a transparent membranous capsula, and lodged in the anterior fossula of the vitreous humour, as has been already said. It is very improperly called *an humour*, because it may be handled and moulded into different shapes by the fingers, and sometimes almost dissolved by different reiterated compressions, especially when taken out of the capsula; but the centre is of a harder consistence than the rest.

The

The figure of the crystalline is lenticular; but its posterior side is more convex than the anterior, the convexity of both sides being very rarely equal. Steno observed, that the lens was composed of concentric lamellæ; and this has been confirmed by later authors: and Zinn has discovered radiated streaks of a pearl colour, dividing the lens into little triangles. See Zinn de Oculi, tab. vii. fig. vii.

The colour and consistence of the crystalline varies in different ages, as was discovered by M. Petit the physician. (See Memoirs for 1726.) Till the age of 30 it is very transparent, and almost without any colour. It afterwards becomes yellowish, and that yellowness gradually increases. The consistence varies almost in the same manner, being of an uniform softness till the age of 20, and afterwards growing gradually more solid in the middle of the mass; but in this there are varieties, explained in the Memoirs for 1727. Haller takes notice of a watery liquor situated betwixt the crystalline lamellæ, which in old age turns of its own accord to a yellow colour; and Steno and Morgagni describe a little water effused betwixt the lens and its capsul.

The crystalline capsula or coat is formed by a duplicature of the tunica vitrea, or of a proper capsul to which the tunica vitrea is connected. The anterior portion of the crystalline capsula is thicker than the posterior, and, in a manner, elastic; and both its thickness and elasticity may be discovered in dissection, without any other artifice.

The anterior portion swells when macerated in water, and then appears to be made up of two pelliculæ, united by a fine spongy substance. "I demonstrated this duplicature (says Winslow) very plainly in the eye of an horse by the knife alone; and I even carried the separation of the two laminæ as far as the vitreous coat. Having made a small hole in the middle of the capsula
of

of an ox's eye, and blown into it through a pipe, some part of the air remained between the edge of the crystalline mass and that of the capsula in form of a transparent circle."

The aqueous humour is a very limpid fluid, resembling a kind of lymph or serum, with a very small degree of viscosity; but in the foetus, for a short time after birth, it is of a reddish colour. (See Petit, Memoirs for 1727.) It appears to come from the arteries of the iris. Winslow and others were of opinion, that it has no particular capsula like the crystalline and vitreous humour; but from observations lately made in a memoir presented to the Royal Academy of Sciences in 1760, it appears that the inner side of the cornea and anterior surface of the iris are covered with an exceedingly fine membrane, supposed to come from the choroid: whether it goes into the posterior chamber, is doubtful. The aqueous humour fills the space between the cornea and iris, that between the iris and the crystalline, and the hole of the pupilla. These two spaces are called the *chambers of the aqueous humour*, and they are distinguished into the anterior and posterior.

The two chambers are not of the same extent. The anterior, which is visible to every body between the cornea and iris, is the largest; the other between the iris and crystalline is very narrow, especially near the pupilla, where the iris almost touches the crystalline. This proportion between the two chambers has been sufficiently proved, contrary to the opinion of many ancient writers, by M. Heister, Morgagni, and several members of the Royal Academy; but none has treated these matters at so great a length as M. Petit the physician, as appears by the printed memoirs of that Society.

§ 5. *The Tunica Albuginea, and Muscles of the Globe of the Eye.*

THE tunica albuginea, called commonly the *white of the eye*, and which appears on all the anterior convex side

side of the globe, from the cornea to the beginning of the posterior side, is formed chiefly by the tendinous expansion of the four recti-muscles. This expansion adheres very close to the sclerotica, and makes it appear very white and shining, whereas the rest of it is of a dull whitish colour. It is very thin near the edge of the cornea; in which it seems to be lost, terminating very uniformly.

There are commonly six muscles inserted in the globe of the human eye; and they are divided, on account of their direction, into four recti and two obliqui. The recti are again divided, from their situation, into superior, inferior, internal, and external; and, from their functions, into a levator, depressor, adductor, and abductor. The two oblique muscles are denominated from their situation and size, one being named *obliquus superior* or *major*, the other *obliquus inferior* or *minor*. The *obliquus major* is likewise called *trochlearis*, because it passes through a small cartilaginous ring, as over a trochlea or pulley.

The musculi recti do not altogether answer to that name; for in their natural situation they do not at all lie in a straight direction, as they are commonly represented in an eye taken out of the body. To understand this, we ought to have a just idea of the situation of the globe in the orbit, and at the same time to remember the obliquity of the orbits, as already explained. The globe is naturally placed in such a manner, as that, during the inaction or equilibrium of all the muscles, the pupilla is turned directly forward; the inner edge of the orbit is opposite to the middle of the inside of the globe; the outer edge of the orbit, because of its obliquity, is behind the middle of the outside of the globe; and lastly, the great circumference of the convexity of the globe between the pupilla and the optic nerve, runs directly inwards and outwards, upwards and downwards.

In this situation, the adductor alone is in a straight direction,

direction, the other three being oblique; and the abductor is the longest, the adductor the shortest, and the levator and depressor of the same middle length between the two former. The abductor is likewise bent round the outer convex side of the globe; the levator and depressor are also incurvated, but in a less degree; whereas the whole adductor is almost straight. The superior oblique are situated so as to serve as antagonists to the former. (See Description of the Muscles, vol. I.)

Uses of these muscles. The levator moves the anterior portion of the globe upward when we lift up the eyes; the depressor carries this portion downwards; the adductor toward the nose, and the abductor towards the temples.

When two neighbouring recti act at the same time, they carry the anterior portion of the globe obliquely toward that side which answers to the distance between these two muscles: and when all the four muscles act successively, they turn the globe of the eye round, which is what is called *rolling the eyes*.

It is to be observed, that all these motions of the globe of the eye are made round its centre; so that in moving the anterior portion, all the other parts are likewise in motion. Thus, when the pupilla is turned toward the nose or upward, the insertion of the optic nerve is at the same time turned toward the temple, or downward.

The use of the oblique muscles is chiefly to counterbalance the action of the recti, and to support the globe in all the motions already mentioned. This is evident from their insertions, which are in a contrary direction to those of the recti, their fixed points with relation to the motions of the globe being placed forward, and those of the recti backward, at the bottom of the orbit. The soft fat which lies behind the globe is altogether insufficient to support it: neither is the optic nerve more fit for this purpose; for I have shown that this nerve

follows all the motions of the globe, which would be impossible, were not the fat very pliable and without resistance. And to this we must add, that the optic nerve at its insertion in the globe has a particular curvature, which allows it to be elongated, and consequently prevents it from suffering any violence in the different motions of the eyes.

The obliquity of these two muscles does not hinder them from doing the office of a fulcrum; because this is not a fulcrum distinct from the part moved, or on which the globe of the eye slides like the head of one bone in the articular cavity of another; but being fixed to the part, it easily accommodates itself to all the degrees of motion thereof. Had these muscles lain in a straight direction, they would have incommoded the recti; but their obliquity may be said to be in some measure rectified by the inner surface of the orbit, and the rectus externus.

The inner surface of the orbit serves for a kind of collateral fulcrum, which hinders the globe from falling too far inward; as the joint action of the two obliqui prevents it in part from falling too far outward. The rectus externus, by being bent on the globe, not only hinders it from being carried outward, but also prevents the indirect motions of the obliqui from thrusting it out of the orbit toward the temples. The other uses attributed to these muscles seem to be without foundation, from the consideration of their insertions, and of the structure of the parts with which they are concerned; both which reasons are explained in the Memoirs of the Academy for 1721.

§ 6. *The Supercilia, and Musculi frontales, occipitales, and superciliares.*

Supercilia. THE supercilia or eye-brows are the two hairy arches situated at the lower part of the forehead,

between the top of the nose and temples, in the same direction with the bony arches which form the superior edges of the orbits, and are peculiar to the human species. The skin in which they are fixed does not seem to be much thicker than that of the rest of the forehead; but the *membrana adiposa* is thicker than on the neighbouring parts. The colour of the eye-brows is different in different persons; and often, in the same person, different from that of the hair on the head; neither is the size of them always alike. The hairs of which they consist are strong and pretty stiff; and they lie obliquely, their roots being turned to the nose, and their points to the temples.

The *supercilia* have motions common to them with those of the skin of the forehead, and of the hairy scalp. By these motions the eye-brows are lifted up; the skin of the forehead is wrinkled more or less regularly and transversely; and the hair and almost the whole scalp is moved, but not in the same degree in all persons; for some by this motion alone can move their hat, and even throw it off from their head. The eye-brows have likewise particular motions which contract the skin above the nose; and all these different motions are performed by the occipital and fontal muscles. (*See Vol. I.*)

The occipital and frontal muscles appear to be true *digastrici*, both in regard to their insertions and action. The fixed insertions of the occipitales at the lower part of the occiput, and the moveable insertions of the frontales in the skin of the forehead and of the *supercilia*, being well considered, together with their reciprocal insertions in the same aponeurosis, seem to be a very convincing proof that they are *digastric* muscles.

These four muscles seem always to act in concert, the occipitales being only auxiliaries or assistants to the frontales, the office of which is to raise the *supercilia* by wrinkling the skin of the forehead; these wrinkles

kles following the direction of the eye-brows pretty regularly in some subjects, and very irregularly in others.

To be convinced of the co-operation of these four muscles, we need only hold the hand on the occipitales, while we raise the eye-brows and wrinkle the forehead several times; and we will perceive the occipitales to move each time, though not in the same degree in all subjects. In some persons the occipitales seem to be relaxed, while the frontales being in contraction move the whole scalp and pericranium forward, and then contract to bring them back to their natural situation.

The action of the musculi supereiliares is to depress the eye-brows, to bring them close together, and to contract the skin of the forehead immediately above the nose into longitudinal and oblique wrinkles, and the skin which covers the root of the nose into irregular transverse wrinkles. This action, as well as that of the frontales, and of the muscles of the nose and lips, is not always arbitrary, but sometimes mechanical and involuntary. These muscles may perhaps likewise serve to keep the musculi frontales in equilibrio during their inaction, they being moveable by both extremities.

§ 7. *The Palpebræ and Membrana conjunctiva.*

Palpebræ. THE palpebræ are a kind of veils or curtains placed transversely above and below the anterior portion of the globe of the eye; and accordingly there are two eye-lids to each eye, one superior the other inferior. The superior is the largest and most moveable in man. They both unite at each side of the globe; and the places of their union are termed *angles*, one large and internal which is next the nose, the other small or external which is next the temples.

Structure of the palpebræ. The palpebræ are made up of common and proper parts. The common parts are the skin, epidermis, and membrana adiposa. The proper parts are the muscles, the tarfi, the puncta or foramina lacrymalis, the membrana conjunctiva, the glandula lacrymalis, and the particular ligaments which sustain the tarfi. The tarfi and their ligaments are in some measure the basis of all these parts.

Tarfi. The tarfi are thin cartilages, forming the principal part of the edge of each palpebra; and they are broader at the middle than at the extremities. Those of the superior palpebræ are something more than a quarter of an inch in breadth; but in the lower palpebræ they are not above the sixth part of an inch; and their extremities next the temples are more slender than those next the nose.

These cartilages are suited to the borders and curvature of the eye-lids. The lower edge of the superior cartilage, and the upper edge of the inferior, terminate equally, and both may be termed the *ciliary edges*. The opposite edge of the upper tarsus is something semi-circular between its two extremities; but that of the inferior tarsus is more uniform, and both are thinner than the ciliary edges. Their inner sides, or those next the globe, are grooved by several small transverse channels, of which hereafter; and the extremities of both cartilages are connected by a kind of small ligaments.

Ligamenta tarforum lata. The broad ligaments of the tarfi are membranous elongations formed by the union of the periosteum of the orbits and pericranium along both edges of each orbit. The superior ligament is broader than the inferior, and fixed to the superior edge of the upper cartilage, as the inferior is to the lower edge of the lower cartilage; so that these ligaments and the tarfi, taken alone or without the other parts, represent palpebræ.

Mem-

which till of late years was not known, is yellowish, and of the number of those called *conglomerate glands*. It lies under that depression observable in the arch of the orbit near the temples mentioned in the description of the skeleton, and laterally above the globe of the eye. It is a little flattened, and divided as it were into two lobes; one of which lies toward the insertion of the *musculus rectus superior*, the other toward the *rectus externus*. It adheres very closely to the fat which surrounds the muscle and posterior convexity of the eye, and it was formerly named *glandula innominata*.

From this gland several small ducts go out, which run down almost parallel to each other, through the substance of the *tunica interna* or *conjunctiva* of the superior palpebra, and afterwards pierce it inwardly near the superior edge of the tarsus. Steno discovered the excretory ducts of this gland upon the eye of an ox; and they are painted by Bidloo 1661. In man, however, they are seen with more difficulty; for although described by Winslow and Lieutaud, they were unknown to later authors, as Morgagni, Zinn, and Haller, till Dr Monro, the present professor, discovered and injected them before the year 1753. They are six or seven in number, have no communication with each other, and open upon the inner side of the upper eye-lid near the outer angle.

The borders of each palpebra taken together are formed by the edge of the tarsus, and by the union of the internal membrane with the skin and epidermis. This border is flat, and of some sensible breadth from within about a quarter of an inch of the internal angle, all the way to the external angle, near which the breadth diminishes. This breadth is owing only to the thickness of the palpebræ, which at this place have their edges oblique or slanting, in such a manner as when the two palpebræ touch each other slightly, a
tri-

triangular space or canal is formed between them and the globe of the eye.

Cilia. The flat edge of each palpebra is adorned with a row of hairs called *cilia*, or the *eye-lashes*. Those belonging to the superior palpebra are bent upward, and longer than those of the lower palpebra which are bent downward. These rows are placed next the skin; and are not single, but irregularly double or triple. The hairs are longer near the middle of the palpebræ than toward the extremities; and for about a quarter of an inch from the inner angle they are quite wanting.

Glandule ciliares. Along the same border of the palpebræ near the internal membrane, or toward the eye, we see a row of small holes, which may be named *foramina* or *puncta ciliaria*. They are the orifices of the same number of small oblong glands which lie in the sulci, channels, or grooves on the inner surface of the tarsus. These little glands are of a whitish colour; and, when examined through a single microscope, they appear like bunches of grapes, those of each bunch communicating together; and when they are squeezed between two nails, a sebaceous matter like soft wax is discharged through the *puncta ciliaria*. They are more numerous in the upper than in the under eyelid, and were first painted by Casserius, but afterwards described by Meibomius, whose name they frequently go under.

Puncta lacrymalia. Near the great or internal angle of the palpebræ, the flat portions of their edges terminate in another which is rounder and thinner. By the union of these two edges an angle is formed; which is not perfectly pointed like a true angle, but rounded; and may be called *the internal or nasal angle*.

At this place, the extremity of the flat portion is distinguished from the round portion by a small protuberance or papilla, which is obliquely perforated by a

small hole in the edge of each palpebra. These two small holes are very visible, and often more so in living than in dead bodies; and they are commonly named *puncta lacrymalia*, being the orifices of two small ducts, called *lacrymal*, which unite beyond the angle of the eye, and open a little below the upper end of a particular reservoir, termed *sacculus lacrymalis*, which shall be described in the article of the *Nose*.

The *puncta lacrymalia* are opposite to each other, so that they meet when the eye is shut. Round the orifice of each of these points, we observe a whitish circle, which seems to be a cartilaginous appendix of the tarsus, and which keeps the orifice always open. These two oblique circles are so disposed, that when the eye is but slightly shut, they touch each other only toward the skin, and not toward the globe of the eye. The fine membrane which covers these circles, and passes through the *puncta* into the ducts, seem sometimes to run into gathers when it is touched with a stilet. This observation was first made by M. Saint Yves a Parisian oculist.

Caruncula lacrymalis. The *caruncula lacrymalis* is a small reddish, granulated, oblong body, situated precisely between the internal angle of the palpebræ and globe of the eye, but it is not fleshy as its name would insinuate. The substance of it seems to be wholly glandular; and it appears through a single microscope, in the same manner as the other conglomerate glands. We discover upon it a great number of fine hairs covered by an oily, yellowish matter, furnished by this gland; and on the globe of the eye, near this glandular body, we see a semilunar fold formed by the conjunctiva, the concave side of which is turned to the uvea, and the convex side to the nose.

This fold, which has the name of *membrana semilunaris*, appears most when the eye is turned toward the nose; it is shaped like a crescent, the two points of which

which answer to the puncta lacrymalia, and conduct the tears into the puncta.

§ 8. *The Muscles of the Palpebra.*

THE muscles of the palpebræ are commonly reckoned to be two; one peculiar to the upper eye-lid, named *levator palpebræ superioris*; the other common to both, called *musculus orbicularis palpebrarum*, which has been subdivided by different authors in different manners. See Description of Muscles, Vol. I.

The skin of the superior palpebra is folded archwise, almost in a parallel direction to that of the semioval fibres; the plicæ intersecting the levator, whereas the other folds only intersect the orbicularis. The radiated and oblique plicæ seldom appear in young persons, except when the first and second portions of the orbicularis are in action; but in aged persons the marks thereof are visible at all times.

In man, the superior palpebra has much more motion than the inferior. The small simple motions, called *twinkling*, which frequently happen, though not equally often in all subjects, are performed by the alternate contraction of the levator palpebræ and orbicularis.

These slight motions, especially those of the upper palpebra, are not very easy to be explained according to the true structure of the part. The motions which wrinkle the palpebræ, and which are commonly performed to keep one eye very close shut, while we look stedfastly with the other, are explicable by the simple contraction of all the portions of the orbicularis. These motions likewise depress the supercilia, which consequently may be moved in three different manners, upwards by the *musculi frontales*, downward by the *orbiculares*, and forward by the *superciliares*.

§ 9. *The*

§ 9. *The Vessels of the Eye and its Appendages.*

THE external carotid artery, by means of the arteria maxillaris externa, and the temporal and frontal arteries, give several ramifications to the integuments which surround the eye, and to all the portions of the musculus orbicularis; and these ramifications communicate with those which are distributed to the membrana conjunctiva palpebrarum, and to the caruncula. Some small branches also come in through the sphena-maxillary future, to be distributed chiefly on the periorbitum and fat of the eye. The internal carotid artery having entered the cranium, sends off a considerable branch called *ocular*, which accompanies the optic nerve, to be distributed to the muscles and globe of the eye, to the levator palpebræ, to the fat, glandula lacrymalis, membrana conjunctiva, caruncula lacrymalis, &c. It likewise communicates with the external carotid, and sends one or two very small branches to the nose. The branches which supply the globe of the eye have the name of *ciliares*; they perforate the back part of the tunica sclerotica in five or six places, after which they run a little way through its substance, where each branch forms a plexus, which sends numerous branches to the choroid.

Dr Wrisberg observes, they next perforate the external lamina of the choroides, and form between that and the internal lamina the vascular stellæ mentioned in the description of this internal lamina. Some small vascular filaments from these ramifications are likewise observed to adhere very closely to the tunica vitrea; and they send small arteries in a direct course to the circumference of the iris, where they form a vascular circle, which sends out capillaries as far as the membrana crystallina, which are very easily injected in new-born children. But the posterior part of the cap-
sul

ful of the lens is supplied from another source; Albinus, and after him many others, have injected in a foetus a branch from the arteria centralis retina, which passes thro' the middle of the vitreous humour, and is dispersed in a radiated manner on the back part of the capsula crystallina. Zinn is of opinion, that these vessels pass also into the body of the lens; but there is no certain proof of this.

The veins of all these parts answer nearly to the arteries; but those of the globe of the eye are called *vasa vorticosa*. The internal veins unload themselves, partly into the internal jugular vein, by the sinus cavernosi; and partly into the external jugular vein, by the vena angularis, or maxillaris externa, the maxillaris interna, temporalis, &c.

Besides the capillary vessels, easily distinguishable by the red colour of the blood, there are great numbers of those which admit nothing but the serous and lymphatic parts of the blood, and consequently do not appear in the natural state. They become visible in some places by inflammations and injections, as on the membrana conjunctiva of the eye; but these contrivances do not discover them every where in aged persons. In a foetus, and in new-born children, says Winslow, a fine injection has succeeded so well as to discover the vessels of the membrana crystallina and vitrea; and in a foetus of about six months, the injected liquor seemed to me to have penetrated a part of the crystalline and vitreous humour.

§ 10. *The Nerves of the Eye and of its Appendages.*

BESIDES the optic nerve already described, the globe of the eye receives several small ones, which run on each side along and about the optic nerve, from its entry into the orbit to its insertion in the globe. These filaments come chiefly from a small lenticular ganglion,
formed

formed by a very short rami of the orbitary or ophthalmic branch of the fifth pair, and by a branch of the third pair, or *motores oculi*.

The nerves of the lenticular ganglion having reached the globe of the eye, are divided into five or six fasciculi; which having surrounded the optic nerve, and penetrated and perforated the sclerotica, run at distances more or less equal between the sclerotica and choroides towards the iris. There each of them is divided into several short filaments, which terminate in the substance of the iris. These small nerves, which run from behind forward between the sclerotica and the choroides, have formerly been taken for particular ligaments by anatomists of considerable eminence; but are now known under the name of *ciliary nerves*.

The nerves which go to the other parts belonging to the eye, come from the third, fourth, sixth, and first two branches of the fifth pair of nerves, and likewise from the portia dura of the seventh pair. The third, fourth, and sixth pairs give nerves to the muscles of the globe of the eye. The two branches of the fifth pair, and the portio dura of the seventh, give nerves not only to the other parts which surround the globe, but also to the muscoli frontales and internal parts of the nose.

The trunk of the third pair, or motor oculi, having entered the orbit through the superior orbitary fissure, or foramen lacerum of the sphenoid bone, produces four branches. The first runs upward, and divides into two; one for the musculus levatur oculi, and the other for the levator palpebræ superioris. The trunk continuing its course, gives off the second short branch to the depressor oculi. The third branch is long, and goes to the obliquus inferior, contributing likewise to the formation of the lenticular ganglion already mentioned. The fourth branch is large, and supplies the adductor oculi.

The

The first branch of the fifth pair, commonly termed *nervus ophthalmicus*, divides into three rami, as it enters the orbit; and sometimes only in two, one of which is afterwards subdivided. Of these three branches one is superior, and termed *nervus superciliaris*; one internal, termed *nasalis*; and one external, to which the name of *temporalis* or *lacrymalis* is applied.

The superior or superciliary ramus runs along the whole periosteum of the orbit; and having passed thro' the superciliary notch or foramen of the os frontis, is distributed to the musculus frontalis, superciliaris, and superior portion of the orbicularis palpebrarum; and it communicates with a small branch of the portio dura of the seventh pair.

The internal or nasal branch passes under the ramification of the nerve of the third pair; and running toward the nose, is distributed thereto, and to the neighbouring parts of the orbicularis, the caruncula, &c. This branch sends off a filament, which, passing thro' the internal anterior orbitary hole, enters the cranium, and presently returns again through one of the ethmoidal holes to the internal parts of the nose. Sometimes this nasal ramus communicates with the ramus superciliaris by a particular arch, before it enters the orbitary hole.

The external or temporal ramus, which is sometimes a subdivision of the superciliaris, is distributed to the glandula lacrymalis, and sends off a filament which pierces the orbitary apophysis of the os maxillæ.

The second branch of the fifth pair, called *nervus maxillaris superior*, sends off a ramus through the bony canal of the lower part of the orbit; which going out at the anterior inferior orbitary hole, is distributed to the neighbouring portion of the musculus orbicularis, and communicates with a ramus of the portio dura. The rest of the superior maxillary nerve shall be described afterwards.

The

The portio dura of the seventh pair, or auditory nerve, gives branches to the superior, inferior, and external lateral parts of the orbicularis palpebrarum; one of which communicates with the nervus superciliaris, and another with the sub-orbitarius, to be afterwards described.

§ 11. Sight.

EVERY one knows that the eye is the organ of vision. The greater part of it is composed of pellucid humours capable of refracting the more subtle medium of light. The complexity of this organ is necessary for the defence of its tender parts, and from the diversity of the several humours to be contained each in their proper integuments.

Outwardly, a defence is afforded to this organ by the eye-brow or *supercilium*; and the thick hairs placed there, which are capable of being pulled down by the action of the frontal, corrugator, and orbicular muscles, so as to afford a shade to the eye in too strong a light. After this office is finished, the eye-brow is raised again by the insertion of the frontal muscle, which, being of a long quadrangular figure, is drawn backward by the occipital muscle. A depression of the eye-brow serves also to express concern of the mind; as an elevation of it denotes the mind to be in a serene quiet state. This guard also conduces to throw off the sweat and retained dust, or the insects which might fall into the eye.

The palpebræ are placed still nearer guards to the eye; and that they might shut together more exactly, they have each of them a cartilaginous arch, called *tarsus*, upon their margins, which meet together. It hinders the eye-lid from falling into wrinkles while it is elevated or depressed. The elevation of the upper eye-lid is performed by a muscle arising from the involu-

lucrum of the optic nerve gradually spreading, and extended by its expansion to the tarsus. This elevator is considerably assisted in its action by the frontalis, and by various connections with the orbicularis drawn up or dilated by the former. The upper eye-lid is depressed by the *orbicularis* muscle; which also serves to elevate the lower eye-lid, and covers the eye in such a manner that no dust or light can enter it in sleep. The lower eye-lid is depressed by a double portion of fibres, inserted into the upper-lip.

Finally, that the protuberant margins of the eye-lids might not injuriously beat against each other, the *cilia* are placed so as to make a blind or shade. These are of use in more distinct vision, by excluding the extraneous rays, when we require a distinct representation of any object.

That the eye-lids rubbing against each other might not grow together, they are supplied with a row of *sebaceous glands*. These discharge a soft liniment, which mixes and washes off with the tears.

But the perpetual attrition of the eye-lids ascending and descending against the globe of the eye, is prevented by the *tears*; which preserve also the tenderness of the membranes and of the cornea, and serve to wash out any insects or other sharp corpuscles. These form a saline pellucid liquor that may be evaporated, and never ceases to be poured over the anterior surface of the eye; but never runs over the cheeks, unless collected together in a larger quantity from some cause. This liquor is exhaled partly from the arteries of the conjunctiva, as we see from an imitation of nature by injecting water: and it in part proceeds from the lacrymal gland.

The separation of the tears is increased by the more frequent contraction of the orbicular muscle, either from irritation, or some sorrowful passion; by which means the tears are urged over the whole surface of the eye and conjunctiva, which they wash.

After

After the tears have performed their office, some part of them flying off into the air, the rest, that they might not offend by their quantity, are propelled by the orbicular muscle towards its origination next the nose, to a part which is the lowest of the palpebral margins; which not being surrounded by the tarsus, does therefore not meet exactly together. Here the *caruncula lacrymalis* interposes and separates the meeting of the eye-lids, at the same time furnishing a liniment to those parts which have none of the Meibomian ducts. Before this part is extended a small portion, like a little eye-lid; which, descending perpendicularly, joins the true eye-lids, and is larger in beasts than in men: but at the beginning of this space, betwixt the eye-lids, appears the *punctum lacrymale*, which drinks up the tears from the sinus in which they are collected; and this partly by tubular attraction, and partly by impulse from the orbicular muscle. If these points or openings are obstructed, the tears run over and excoriate the cheek.

From both points proceeds a small duct: these join together, and are inserted by two mouths near the uppermost part of the *lacrymal sac*, which descends a little backward into the nares, opening there by an oblique oblong aperture at the bottom of the meatus, covered by the lower os spongiosum. Through this passage the superfluous tears descend into the nose, which they in part moisten. A muscle is by some ascribed to this sac; but it is not yet sufficiently confirmed. Some late authors have compared the lacrymal sac to the bladder of urine, which retains its contents for a considerable time, till it is thrown out, the sphincter being relaxed. A similar sphincter has been ascribed to the nasal duct, which is sometimes shut and again relaxed, that the tears collected in the sac may run out through the nostrils.

The globe of the *eye*, compressed before, but longer than

than it is broad; is seated in the cavity of a bony orbit. But as this is larger than the eye itself, the excess is on all sides occupied by a very soft fat, surrounding the globe of the eye, that it may both fill and have a free motion within the orbit.

Among the coats of the eye, the iris is the only one possessing motion. Though it has little sensation, and is not endowed with any mechanical irritability; yet in a living man, quadruped, or bird, it is constricted on every greater degree of light, and is dilated on every smaller one; hence it is rendered broader for viewing distant objects, and narrower for viewing such as are near. The cause of this dilatation seems to be a remission of the powers resisting the aqueous humour; an argument of which, is the dilation of the pupil, occasioned by debility, and which succeeds syncope and death. The contraction is more obscure, and perhaps only depends on the stronger afflux of humours into the colourless vessels of the iris, into which these vessels are extended; and, along with these, the iris is rendered longer, and shuts the greater part of the pupil: so that this motion has something in common with a beginning inflammation. The pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it is rendered almost immovable. In an animal twenty or thirty hours dead, Dr Haller has seen the iris extend by heat, and shut the pupil.

With respect to the origin of the black pigment, we are as yet unacquainted with it; nor can any glandules be found, which some have assigned for its separation. Among its other uses, one seems to be to keep firm the crystalline lens. In infants, this same mucus has the image of a radiated flower behind the ciliary process.

But the *retina*, which is truly a continuation of the medulla from the optic nerve, immediately embraces

the vitreous humour. Here Dr Haller describes the retina as running as far as the surface of the crystalline lens; while Dr Monro observes, that it ends some way behind the ciliary circle.

That the action of the eye lies wholly in the reception of light, excepting only a few doubts, appears very plainly from physical and mechanical experiments. Light is a matter either the same with, or very nearly approaching to, that of fire, extremely fluid and subtile, penetrating through all even the hardest bodies, without receiving alteration from any length or distance in its course; moving with such a very great velocity, as to run through the distance between the sun and earth in the space of about eight minutes and thirteen seconds. The light we have in our atmosphere proceeds either from that of the sun, whose body seems to have the power of impelling to us, in right lines, the matter of light, which is confusedly spread around; or else it proceeds from some other ignited point or lucid body; from whence the rays spread every way, as from a centre to all points of a large sphere, so as to fall upon the surfaces of bodies; from whence again it is reflected into the eye, from the enlightened surfaces, in angles equal to that of their incidence, so as to render the bodies from whence it thus flows to the eye both visible and of some colour.

It is now sufficiently evidenced from experiments, that light is composed of rays in right lines, almost without any physical breadth or thickness; and yet, that each of these rays is again separable into seven other permanent and immutable rays of a lesser kind. The known properties of these rays are, that all of them, conjoined together, constitute a white beam; which, being refracted by the minute surfaces of bodies, are subdivided into rays of a red colour, which are more constant or permanent, hard, and less refrangible; next to which follow those of an orange, of

a yellow, green, blue, and indigo or violet colour; of which those are always weaker and more refrangible, which are farther distant in order from the red rays. A shadow arises from a deficiency in the reflected rays. Those primitive rays, variously compounded together with shade, make up all the variety of colours.

The colours, then, which seem proper to bodies, arise hence; that the minute surfaces of their constituent solid particles, by which their pores or vacuities are limited, do, according to the difference of their thickness, density, &c. reflect or separate the rays of light, so as to send more of one kind or colour to the eye than another; whilst most part of the remaining rays are lost by repeated reflections within the pores of the substance: so that the strongest and thickest particles reflect a white colour; those next in density and size, a red colour; till at last the minutest surfaces reflect a violet colour. Those bodies are opaque, which retain the rays within their substance, without permitting any to pass through them: which seems to follow from the largeness and the number of the pores, to the sides of which the light is attracted; which pores are filled with some matter that has a power of refraction, different from that which the light suffers from the parts of the body itself. These principles we embrace, till a new theory that places the diversity of colours in vibrations of different celerities shall be better established; neither is it our business to concern ourselves with this matter.

These rays, falling obliquely upon the surface of liquors of various densities, pass through them with a change in their direction, by variously receding from or approaching nearer to a perpendicular: and this is called their *refraction*. In general, the denser the medium, the more are the rays bent towards the perpendicular; excepting only inflammable liquors, which,

by a peculiar property, draw the rays more to a perpendicular than in proportion to the density of the liquor. The proportions of the angles of incidence to those of refraction are observed to be constant enough; so that the sine of the radius of refraction from air into water is to the sine of the angle of incidence as 3 to 4: and in the radius, passing from air into glass, the sine of the incidence is to that of refraction as 17 to 11; and from water into glass, as 51 to 44.

Rays, which come through the air with but little divergency, (as those of the sun do on account of their immense distance, or as in general do any rays that come from the distance of above 100 feet), falling out of the air upon denser bodies, spherically convex, are reflected to greater angles, as of $48\frac{1}{2}$ degrees; nor are they under that measure. If the angles are smaller, and they penetrate the refracting medium, they are there so refracted, as to meet together in one point, which is called their *focus*. This point always falls within the axis or radius that is perpendicular to the surface; whence it becomes permanent and unchangeable. So that the focus of rays, passing from air into a sphere of water, will be distant from the axis one semidiameter of the sphere; and in a globular glass, it will be distant a fourth part of the diameter: but in a convex lens of glass, that is, part of a sphere not less than thirty degrees, and equally convex, the focus will be likewise distant one semidiameter; yet so that the rays will meet, not in a single point, but in a little circle.

Therefore the rays of light, whether direct or inflected, fall in such a manner upon the tunica cornea of the eye, as to form a most sharp cone betwixt the lucid point and the membrane upon which they are spread: the basis of which cone will be the surface of the cornea, and the apex in the radiant point; yet so that all rays in this cone may, without any sensible error,

ror, be reckoned parallel with each other. Among these, there are some rays reflected back from the cornea, without ever penetrating the surface; namely, all such as fall upon that membrane in a greater angle than that of forty degrees. Others, which enter the cornea at very large angles, but less than the former, and fall in betwixt the iris and sides of the crystalline lens, are suffocated or lost in the black paint that lines the iris and the ciliary processes; but those rays only fall upon the surface of the lens, which enter the cornea at small angles, not much distant from the perpendicular, or at most not exceeding twenty-eight degrees. By this means, all those rays are excluded which the refracting power of the humours in the eye could not be able to concentrate or bring together upon the retina; without which they would paint the object too large and confusedly.

Those slender rays, therefore, coming thus to the thick cornea, which is denser than water, and forms the segment of a sphere, suffer thus a greater power of refraction, and pass through it in a more considerable degree towards the perpendicular; namely, about a fourth part: but these rays falling with but little convergency upon the aqueous humour, which is small in quantity and almost like water, making there no focus, because of the nearness of the humour to the cornea, go on nearly parallel, or little converging, to the next adjacent surface of the very pellucid or crystalline lens; because their divergency was considerably corrected by the refracting power of the cornea. Moreover, the cornea being convex, and part of a less sphere than that of the sclerotica, receives and collects a greater number of rays than if it was flatter with a less surface.

The refracting power of the crystalline lens, which exceeds that of water, may be understood from its greater hardness and weight; although we have no certain measure. In this lens, therefore, and more

especially in its posterior very convex side, the rays will converge greatly, and pass thence into the vitreous body.

This vitreous body is denser than water, in which it sinks to the bottom; but rarer than the crystalline lens; and continues to bend the rays a little more gently towards the perpendicular, till at length the rays coming from the point of distinct vision, are concentrated into a very small part of the retina, where they paint an image of that object from whence they come; but in a position inverted, from the necessary decussation or crossing of the rays. The manner in which the images of objects are thus painted, may be seen experimentally in an artificial eye, or by a natural eye when the back part of the sclerotica is cut off, and a piece of paper placed to receive the object. But the image we see is painted on the outer side from the optic nerve within the bounds of the visual axis; yet so that it is not a mere point, but has some degrees of breadth; since we see many objects at once, whose images must be in distinct points of the painted field. And there an object is seen most distinctly, because the rays arrive thither nearly perpendicular. But frequently this point of vision does not fall on the same place on both of the eyes. When the lens has been couched or displaced, the vitreous body, with a weaker refracting power, usually suffices to bring the visual rays together to a focus.

Is it altogether false that the object is painted on the retina? Or is this picture made on the choroides? Is this new opinion confirmed by an experiment, by which it is found that the place where the optic nerve enters is blind? and which is thus explained, that there is in that place no choroides but the bare retina, and that thence there is no vision. But this is repugnant to a very well known observation, namely, that the retina is a most sensible nervous medulla; and that the choroides consists almost entirely of a few small nerves,
and

and of vessels most certainly blind. This is likewise contradicted by the very great variety of the choroides in animals; the equally great constancy of the retina; and the black spots, which, even in man, obscure the exterior surface of the retina. But by this experiment we know the reason why the optic nerve is not inserted into the axis of the eye, but into its side. For thus, except only in one single case, where there is an impediment in the concourse of lines drawn through the centre of the optic nerves, the one eye sees and assists that whose blind side is turned towards the object.

But since the necessary offices of human life require a distinct object to be painted upon the retina, not only by the rays which come from one certain distance, but likewise by rays which come from very different parts more or less distant; therefore, it is to be believed, that the necessary change is produced in the eye by its own proper causes. Other famous anatomists have supposed the lens moveable by the powers before mentioned. This art of seeing distinctly is said to be learned by experience, it being unknown to an eye lately couched of a cataract. Also, in an artificial eye, the use and necessity of this motion, it is said, may be plainly perceived. Therefore too great a divergency of the rays, as in those which come from objects very close to the eye, is corrected by a removal of the lens farther from the retina, so as to bring the focus of the diverging rays upon the retina itself, which would otherwise have fallen behind the eye; for the refracting power of the eye being determined, that which will unite the focus of rays coming from the distance of three feet, so as to make them fall perfectly upon the retina, will not be able to collect together into the same point those rays which come from the distance of three inches; and rays still more diverging will meet together yet farther behind the

eye, if they are not collected together by a greater refracting power.

But those rays, which come from parts very remote, and which may be therefore counted parallel, will meet together before the retina, in the vitreous body; and again separate according to the nature of rays from the point of concurrence, as if it was a lucid point: to remedy which, therefore, it is probable that those powers remove the crystalline lens back from the cornea nearer to the retina; that the rays, which come together from a certain distance to the lens, may be also united together at a certain proportionable distance on the retina. For an eye, that will collect the rays coming from seven inches, so as to unite them on the retina, will collect those together before the retina which come from a distance of three feet. It was therefore perfectly necessary for the eye to be made thus changeable, that we might be able to see distinctly at various distances. But the point of distinct vision is in that part of the retina where the given object is painted in the least compass possible. The powers causing the visual rays to unite or converge on the retina, are often very different in the two eyes of one and the same person, so as to render one eye nearly presbyoptical or long-sighted, and the other myoptical or short-sighted.

These and other things similar are commonly received and taught, more especially by the mathematicians, who more readily perceive the necessity of these changes. But yet there is no power in the human eye which can either move the crystalline humour out of its place, or compress it. But we do not perceive this faculty in ourselves: for we move a book nearer to our eyes when it is too far off, so as to appear confused; which we would have no occasion to do, if by changing the internal figure of the eye we could correct the fault of the distance: and through a small hole, we perceive an object only single in the point
of

of distinct vision, but double in every other. Perhaps the contraction of the pupil may do something, by which we can perceive more distinctly such objects as are near.

But this artifice of the eye is not sufficient in all persons. For there are now a greater number of people than formerly employed in a studious or sedentary life, and taken up with the observation of more minute objects; by which the cornea is rendered more convex and dense, and the crystalline lens more solid and of less segments; while the eye itself, by the weight of the humours, is more elongated, and the rest of the humours themselves are probably more densified: many or all of which circumstances attend the eyes of one person. In such, the iris is sensible in a small light; whence, by winking, or straining the eye-lid, they are denominated *myopes*, short or near sighted. In these, the point of distinct vision is very near to the eye, from one to seven inches from before the cornea; but they see remoter objects more obscurely, without being able to distinguish their parts. The reason of this is evident; since, from the forementioned causes, there is a greater refracting power of the humours, by which the distant and consequently parallel rays are obliged to meet in their focus before the retina; from whence spreading again, they fall upon the retina in many points. Thus also to a good eye, the sense of objects which are too near the cornea is confused; because the rays coming from thence are spread all over the retina, without being collected towards the centre.

The remedy for this fault in the sight is to correct it in its beginning, by viewing distant places, by keeping the eyes from minute or near objects, and by the use of concave glasses; or by viewing things through a small hole, by which the light is weakened. When the disorder is confirmed, the remedy is a concave lens, which takes off a degree of the refracting power in the humours, cornea, and crystalline lens, in proportion

tion as it is more concave ; by which means the focus of rays from remote objects is removed farther behind the cornea, so as to fall upon the retina. This glass ought to be a portion of a sphere, whose diameter is equal to the distance of distinct vision from the naked eye, squared by the distance of distinct vision in the armed eye, and divided by the difference betwixt them. Age itself advancing, gives some relief to the short-sighted ; for children are in a manner naturally myoptical : but, as the eye grows older, it becomes flatter, in proportion as the solids grows stronger ; and, contracting to a shorter axis, the converging powers of the lens and cornea are diminished.

Another disorder of the sight, contrary to the former, troubles people who are often looking upon very distant objects, and is more especially familiar and incurable in old people. In such, the cornea and crystalline lens are flatter, and the humours of the eye have a less refracting power. Hence near objects, whose rays fall very diverging upon the cornea, appear confused ; because the converging or refracting powers of the eye are not sufficient to bring the rays together in a focus upon the retina, but the rays go on scattered through the retina, and through the point of their pencil behind the eye ; from whence vision is confused. The point of distinct vision among presbyopi, or old or long-sighted people, is from the distance of fifteen inches to three feet.

Such persons are, in some measure, relieved by looking through a black tube held before the eye ; by the use of which the retina grows tenderer, and the rays come to the eye in a parallel direction. The remedy here is a convex lens of glass, which may cause the rays to converge and unite together sooner in a focus, that it may not fall behind the eye, but upon the retina. The diameter of the sphere, of which such a lens ought to be a portion, is determined as before.

There

There is no hope from age, which increases the malady.

The medium betwixt short and long sighted is the best, by which a person can see distinctly enough objects that are both near and remote ; and of this kind we reckon an eye that is able to read distinctly at the distance of one foot. But to this are to be added other necessary conditions ; such as a perfect clearness of the humours ; a due mobility of the eye itself, and its parts ; a sensibility of the pupil and retina, neither too tender nor too tough.

But the mind not only receives a representation of the image of the object by the eye, impressed on the retina, and transferred to the common sensory or seat of the soul ; but she learns or adds many things from mere experience, which the eye itself does not really see, and other things the mind considers or interprets to be different from what they appear to her by the eye. And first, the *magnitude* of an object is judged of by an optical angle intercepted ; as the basis of a triangle betwixt the cornea, and as the point of a cone betwixt the radiant object. From hence, things very near seem large, and remote objects seem small. Hither may be referred the power of microscopes, by which objects are made to appear to us so much larger, as the distance of the focus of the lens or magnifier is less than the distance of distinct vision ; when, in reality, they do not appear larger, only more distinct and lucid ; whence the mind judges them to be nearer.

The strength of visual light likewise is proportionable to the same angle, in the external day-light ; and the multitude or number of the rays, joined with the smallness of the seat which they affect in the retina, occasions near objects to appear brighter, and distant objects more obscure ; or if remote objects appear bright by their own light, the mind represents them as large, near at hand, or both.

The *place* of a distant object appearing to one eye, is reckoned

reckoned to be in a line comprehended by two other straight lines drawn to the extremities of the body. If the same body is looked upon with both eyes, it will then seem to be in the concourse of two lines drawn through the axis of both eyes to that object.

Distance we cannot perceive; and if a blind man, who never saw, should by any means be restored to sight, he would imagine every thing he saw to touch his eyes. Even we who are accustomed to judge by sight, make many fallacious conjectures concerning the distance of objects: but concerning this we judge as well from the known diminution of the bulk of the body, as from the lesser strength of the light, and faint image of the object whose parts we are less capable of distinguishing, and from the number of bodies interposed, whose distance is known.

The *convexity* or *protuberance* of a body is not seen; but is afterwards judged of by experience, after we have learned, that a body, which is convex to the feeling, causes light and shadow to be disposed in a certain manner. Hence it is, that microscopes frequently pervert the judgment, by transposing or changing the shadows. The same also happens in that phenomenon which is not yet sufficiently understood, by which the concave parts of a seal are made to seem convex, and the contrary.

The visible *situation* of the parts of an object, are judged by the mind to be the same with that which they naturally have in the object, and not the inverted position in which they are painted upon the retina. But it is certainly a faculty innate or born with the eye, to represent objects upright to the mind, whenever they are painted inverted upon the retina; for new-born animals always see things upright. And men who have been born with cataracts, without ever being able to see, are observed, upon couching the cataracts, to see every thing in its natural situation, without the use of any feeling, or previous experiences.

One

One thing which imposes upon the mind, is the continuance which external sensations make, during almost the space of a second of a minute, after they have been conveyed to the sensorium by the eyes; whence they are represented to the mind as objects really present. From hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and from hence proceeds the continuance of the shining image of the sun, and sometimes of other bodies, after they have been viewed by the eye.

Do we perceive only that object distinctly which is directly before that part of the retina which sees most distinctly? And does the eye persuade itself, that it sees many objects at a time, partly from the duration of the ideas, and partly from the quickness of the motions of the eye? Concerning the most distinct vision, this is most certain; but we cannot affirm it of that which is less distinct. Why do we see only one object with two eyes? Because the sensation becomes one, and without difference, when we have similar impressions of two objects. For, even without the concurrence of optic nerves, insects who have numerous eyes perceive objects single. Hence the images of two objects excite only one sensation, when they fall upon the same point of the retina; but two sensations arise from one object, when the images fall upon different parts of the retina. Whence proceed diurnal and nocturnal blindness? The former is common to many nations living in the warmest climates, under the brightest rays of the sun, and to old men. The other happens in inflamed eyes, and young men of a hot temperament, and hence endowed with eyes vastly sensible. Whence do animals see in the dark? From a large dilatible pupil, and tender retina; a shining choroides, and one which reflects the light very strongly. Why are we blind when brought out of a strong light into a weak one? Because the optic nerve, having suffered the action of stronger causes, is incapable of being moved by weaker ones.

Whence

Whence have we a pain, by passing suddenly from a dark place into the light? Because the pupil, being widely dilated in the dark, suddenly admits too great a quantity of light before it can contract; whence the tender retina, which is easily affected by a small light, feels, for a time, an impression too sharp and strong. Whether see we with one eye, or with both? Most frequently with one, and more especially the right eye: but when both are employed together, we see more objects, and more plainly; and we also distinguish more points of the same object, and judge better of their distances.

SECT. III. *The Nose.*

THE parts of which the nose is composed, may be divided in two different ways, viz. from their situation, into external and internal parts; and, from their structure, into hard and soft parts.

The external parts are the root of the nose, the arch, the back or spine of the nose, the sides of the nose or of the arch, the tip of the nose, the alæ, the external nares, and the part under the septum.

The internal parts are the internal nares, the septum narium, the circumvolutions, the conchæ superiores, or ossa spongiosa superiora, conchæ inferiores, the posterior openings of the internal nares, the sinus frontales, sinus maxillares, sinus sphenoidales, the ductus lacrymales, and ductus palatini.

The firm or hard parts are mostly bony, and the rest cartilaginous, viz. the os frontis, os ethmoides, os sphenoides, ossa maxillaria, ossa nasi, ossa unguis, ossa palati, vomer, conchæ inferiores, and the cartilages. To these we may add the periosteum and perichondrium, as parts belonging to the bones and cartilages.

The soft parts are the integuments, muscles, saccu-
lus

lus lacrymalis, membrana pituitaria, vessels, nerves, and hairs of the nares. The bony parts have been all explained in the description of the skeleton; and therefore we need only in this place set down the distribution and disposition thereof, for the formation of some of the principal parts. The septum is formed by the descending lamina of the os ethmoides, and by the vomer; and it is placed in the groove framed by the cristæ of the ossa maxillaria, and rising edges of the ossa palati. The fore part of the nose is formed by the ossa nasi; and the sides, by the superior apophyses of the ossa maxillaria.

The internal nares, or the two cavities of the nose, comprehend the whole space between the external nares and posterior openings, immediately above the arch of the palate, from whence these cavities reach upwards as far as the lamina cribrosa of the os ethmoides, where they communicate forward with the sinus frontales, and backward with the sinus sphenoidales. Laterally, these cavities are bounded on the inside by the septum narium; and on the outside, or that next the cheek, by the conchæ or ossa spongiosa between which they communicate with the sinus maxillaris.

The particular situation of these cavities deserves our attention. The bottom of them runs directly backward, so that a straight and pretty large stilet may easily be passed from the external nares, under the great apophysis of the occipital bone. The openings of the maxillary sinuses are nearly opposite to the upper edge of the ossa malarum. The openings of the frontal sinuses are more or less opposite to and between the pulleys or rings of the muscoli trochleares; and by these marks the situation of all the other parts may be determined.

The inferior portion of the external nose is composed of several cartilages, which are commonly five in number, and of a pretty regular figure. The rest are only additional, smaller, more irregular, and the number of
of

of them more uncertain. Of the five ordinary cartilages, one is situated in the middle, the other four laterally. The middle cartilage is the most considerable, and supports the rest, being connected immediately to the bony parts; but the other four are connected to the middle cartilage, and to each other, by means of ligaments.

The principal cartilage of the nose consists of three parts, one middle and two lateral. The middle portion is a broad cartilaginous lamina, joined, by a kind of symphysis, to the anterior edge of the middle lamina of the os ethmoides, to the anterior edge of the vomer, and to the anterior part of the groove formed by the ossa maxillaria, as far as the nasal spines of these bones. This lamina completes the septum narium, and indeed forms the principal part thereof.

The lateral portions are oblique and narrow, suited to the corresponding parts of the bony arch. Where they join the middle lamina, a superficial groove is observable; which makes them sometimes appear like two distinct pieces, separated from the lamina, though they are really continuous. This shallow groove terminates below by a small crista.

The lateral cartilages are two, on each side of the inferior part of the lamina; one anterior, the other posterior. The two anterior cartilages are very much bent forward, and form what is called the *tip of the nose*; the space between their incurvated extremities being commonly filled with a kind of fatty substance. The two posterior cartilages form the *alæ of the nares*, being pretty broad, and of an irregular figure.

The spaces left between some portions of the anterior and posterior cartilages, those between the posterior cartilages and the neighbouring parts of the ossa maxillaria, and lastly those between these four lateral cartilages and the principal lamina, vary in different subjects; and are filled by small additional cartilages,

the number, size, and figure of which are as various as the interstices in which they lie.

The sub-septum, or portion under the septum narium, is a pillar of fat applied to the inferior edge of the cartilaginous partition, in form of a soft moveable appendix. The thickness of the alæ narium, and especially that of their lower edges, is not owing to the cartilages, which are very thin, but to the same kind of solid fat with which these cartilages are covered. The great cartilage is immoveable by reason of its firm connection to the bony parts of the nose; but the lateral cartilages are moveable, because of their ligamentous connections, and they are moved in different manners by the muscles belonging to them.

The external nose is covered by the common integuments, the skin, epidermis, and fat. The parts which cover the tip of the nose and alæ narium, are pierced with the ducts of a great number of glandulæ sebaceæ, the contents of which may easily be squeezed out by the fingers. All these bony and cartilaginous parts have likewise the common periosteum or perichondrium.

Muscles of the nose. Six muscles are commonly reckoned to belong to the nose; two levatores, two depressores, and two compressores. In very muscular bodies, there are likewise some supernumerary muscles, or small accessorii. The nose may also be moved in some measure by the neighbouring muscles, which in many cases become assistants to the proper muscles of this organ.

The first pair of these muscles raises and dilates the ala of the nares when they act. They likewise wrinkle the skin on the sides of the nose. The second pair have the contrary effect; and the third pair compress the sides of the nose to the septum, as in smelling.

Membrana pituitaria. The membrana pituitaria is that which lines the whole internal nares, the ossa

spongiosa, the sides of the septum narium, and by an uninterrupted continuation, the inner surface of the sinus frontales and maxillares, and of the ductus lacrymales, palatini, and sphenoidales. It is likewise continued down from the nares to the pharynx, septum palati, Eustachian tubes, &c. as we shall show hereafter. It is likewise known by the name of *Schneideriana*, from the anatomist who has given a description of it.

It is termed *pituitaria*, because, through the greatest part of its large extent, it serves to separate from the arterial blood a mucilaginous lymph, called *pituita* by the ancients, which in the natural state is pretty liquid; but it is subject to very great changes, becoming sometimes glutinous or snotty, sometimes limpid, &c. neither is it separated in equal quantities through the whole membrane.

When we carefully examine this membrane, it appears to be of a different structure in different parts. Near the edge of the external nares it is very thin, appearing to be the skin and epidermis in a degenerated state. All the other parts of it in general are spongy, and of different thicknesses. The thickest parts are those on the septum narium, on the whole lower portion of the internal nares, and on the conchæ; and if we make a small hole in it at any of these places, and then blow through a pipe, we discover a very large cellular substance. In the sinuses it appears to be of a more slender texture.

Winslow observes, that on the side next the periosteum and perichondrium, it is plentifully stored with small glands, the excretory ducts of which are very long near the septum narium, and their orifices very visible; and that by applying a pipe to any of these orifices, the ducts may be blown up almost through their whole extent; but that in order to this, the parts must first be very well cleaned and washed in lukewarm water. Sabatier gives somewhat of a different description: He admits of mucous follicles; but says they are
very

very different from those which are properly called glands.

Sinus. The frontal, maxillary, and sphenoidal sinuses open into the internal nares, but in different manners. The frontal sinuses open from above downward, answering to the infundibula of the os ethmoides described in the history of the skeleton. The sphenoidales open forwards, opposite to the posterior orifices of the nares; and the maxillares open a little higher, between the two conchæ or ossa spongiosa. Therefore the sinus frontales discharge themselves most readily when we stand or sit; and the sphenoidales, when the head is inclined forward.

The sinus maxillares cannot be emptied wholly or both at the same time in any one situation. Their opening, which in some subjects is single; in others double, &c. lies exactly between the two ossa spongiosa of the same side, about the middle of their depth: so that when the head is held straight, or inclined forward or backward, they can only be half emptied; but when we lie on one side, the sinus of the opposite side may be wholly emptied, the other remaining full.

It is proper here to observe the whole extent of the maxillary sinus. Below, there is but a very thin partition between it and the dentes molares, the roots of which, in some subjects, perforate that septum. Above, there is only a very thin transparent lamina between the orbit and the sinus. Backward, above the tuberosity of the os maxillare, the sides of the sinus are very thin, especially at the place which lies before the root of the apophyses pterygoides. Inward, or toward the conchæ narium, the bony part of the sinus is likewise very thin.

Sacculus lacrymalis. The lacrymal sacculus is an oblong membranous bag, into which the serous fluid is discharged from the eye through the puncta lacrymalia, already described, and from which the same fluid passes to the lower part of the internal nares. It is si-

tuated in a bony groove and canal, formed partly by the apophysis nasalis of the os maxillare and os unguis, partly by the same os maxillare and lower part of the os unguis, and partly by this lower portion of the os unguis, and a small superior portion of the concha narium inferior. This groove and canal are the bony lacrymal duct, about which beginners should consult what was said in the description of the skeleton.

With respect to the situation of this bony duct. It runs down for a little way obliquely backward, toward the lower and lateral part of the internal nares on each side, where its lower extremity opens on one side of the sinus maxillaris under the os spongiosum inferius, nearly at the place from which a perpendicular line would fall in the interstice between the second and third dentes molares. The upper part of this duct is only an half-canal or groove; the lower is a complete canal, narrower than the former.

The sacculus lacrymalis may be divided into a superior or orbital portion, and an inferior or nasal portion. The orbital portion fills the whole bony groove, being situated immediately behind the middle tendon of the musculus orbicularis. About one-fourth of its length is above this tendon, and the rest below; the upper part is the lacrymal sac properly so called; while the nasal portion, which lies in the bony canal of the nose, being narrower and shorter than the former, is termed *lacrymal duct*: the one is merely a continuation of the other, without any valve, &c. between them.

The orbital portion is disposed at its upper extremity much in the manner of an intestinum cæcum, and at the lower extremity is somewhat narrower than the portio nasalis. Towards the internal angle of the eye, behind the tendon of the orbicular muscle, it is perforated by a small short canal formed by the union of the lacrymal ducts.

The nasal portion becomes gradually larger towards
its

its under end, and having reached the lower part of the bony duct under the inferior concha, is perforated by a round opening; but which at first sight appears oblong, and is considerably smaller than the cavity of the duct.

If a transverse line be drawn between the lower part of the nose and os malæ, and another line be drawn directly upward, opposite to the third dens molaris, or opposite to the second and third, these two lines will intersect each other nearly at the lower extremity of this sacculus.

Sometimes the upper extremity of this bag has been found divided into an anterior and posterior part, by a kind of valvula connivens lying in the anterior portion, a little lower than the tendon of the musculus orbicularis. The small common canal of the two lacrymal ducts opens in the posterior part of this sacculus.

The substance of this sacculus is something spongy or cellulous, and pretty thick, being strongly united by its convex side to the periosteum of the bony canal, which may be very distinctly shown. Sabatier observes, that its substance is similar to that of the membrana pituitaria, and that it is lined with the same kind of mucous within. Its use has been compared by some late writers to that of the bladder of urine, as was mentioned in the description of the eye.

Ductus incisorii. The ductus incisorii, or naso-palatini of Steno, are two canals which go from the bottom of the internal nares cross the arch of the palate, and open behind the first or largest dentes incisorii. Their two orifices may be distinctly seen in the skeleton at the lower part of the nasal fossæ, on the anterior and lateral sides of the cristæ maxillares; and we may likewise perceive their oblique passage through the maxillary bones, and lastly their inferior orifices in a small cavity or fossula called *foramen palatinum anterius*. In fresh subjects they are not so apparent, especially in human

subjects; but in sheep and oxen they are easily discoverable.

Arteries and veins. The arteries of all these parts come chiefly from the external carotid. Those of the external parts of the nose are chiefly branches and rami of the arteria maxillaris externa or angularis, and of the temporalis; and the arteries of the internal parts are branches and ramifications of the maxillaris interna, and likewise small branches from the ocular artery. The veins are, almost in the same manner, branches and ramifications of the external jugular; and they communicate with the orbital sinus, and, by that means, with the sinuses of the dura mater, and with the internal jugulars.

Nerves. The principal nerves belonging to the nose are filaments of the nervi olfactorii, which run down through the holes of the transverse lamina of the os ethmoides, and are distributed to the common membrane of the internal nares, especially to the villous portions thereof. The inner ramus of the orbital or ophthalmic sends a filament through the internal anterior orbital hole into the cranium, which comes out again in company with one of the filaments of the olfactory nerve through the ethmoidal lamina.

This internal ramus advances afterwards toward the os unguis; and is distributed partly to the sacculus lacrymalis, partly to the upper portion of the musculus levator alæ nasi, and of the integuments of the nose. The suborbital nerve, which is a branch of the maxillaris superior, having passed through the inferior orbital hole, sends filaments to the lateral external parts of the nose. Another ramus of the superior maxillary nerve goes to the posterior opening of the nares, being spent on the conchæ and other internal parts of the nose.

The outer part of the nose is supplied by branches from the superior maxillary nerve, or second branch of

of the fifth pair, and by others from the portio dura of the seventh pair.

In animals which smell acutely, the parts of the nose are remarkably large; but the formation of the human head into that of a roundish figure, has in us given to the organ of smelling but a small extent of surface; but to enlarge this the more, nature has made the internal parts of the nose variously hollow and complicated in a surprising manner.

§ 1. *Of Smelling.*

The sense of smelling conduces to the distinguishing prejudicial from salutary food. By it we both discover and are admonished to avoid, before it comes to our taste, what might be otherwise dangerous: and we are especially enabled to avoid any thing of a putrid tendency in our victuals, which to us is of a most pestilent nature, and likewise to discern what are grateful and wholesome aliments; although custom has rendered it more remarkable among brute animals than among men. For men who have been brought up wild by themselves, without debauching the scent by a variety of smells, have been observed to possess that distinguishing faculty in a very infallible degree. Finally, the powers and virtues of medicinal plants are hardly to be better known than by the simple testimony of tasting and smelling. From hence it is, that in all animals these organs are placed together; and from hence the smelling is stronger, and the organs larger, in those animals which are to seek their prey at a considerable distance, or to reject malignant plants from among those that are fit for food.

The sense of smelling is performed by means of a soft pulpy membrane, full of pores and small vessels, which lines the whole internal cavity of the nostrils, being thicker upon the septum and principal convolutions, but thinner in the sinuses. Within this mem-

brane are distributed the vessels and nerves already described.

The nerves of the nose, being almost naked, require a defence from the air, which is continually drawn through the nostrils, and blown out again by the use of respiration. Nature has therefore supplied this part, which is the organ of smelling, with a thick insipid mucus, very fluid in its first separation, and not at all falline, but, by the air condensing into a thick dry crust, more consistent here than in other parts of the body. By this mucus the nerves are defended from drying and from pain. It is poured out from many small arteries of the nostrils; and deposited partly into numerous cylindrical ducts, and partly into round visible cryptæ or cells scattered all over the nostrils. The same flows out all over the surface of the olfactory membrane, which is therewith anointed on all sides. This mucus is accumulated in the night time; but in the day expelled by blowing the nose, or sometimes more powerfully by sneezing; and may offend by its excess or tenuity, or irritate by too great thickness the very sensible nerves, from whence a sneezing is excited for its removal. But the sinuses of this part, which abound with mucus, are this way variously evacuated, agreeable to the different postures of the body; by which always some of them are at liberty to free themselves, whether the head be erect, or inclined forward, or laterally; yet so, that generally the maxillary and sphenoidal sinuses are more difficultly emptied than the rest. Moreover, the tears descend, by a channel proper to themselves, into the cavity of the nose, by which they moisten and dilute the mucus.

The cartilages render the nose moveable by its proper muscles, so as to be raised and dilated by a muscle common to the upper lip, and to be contracted together into a narrow compass by the proper depressor and compressor muscle pulling down the septum. The nose projects

projects like an engine in the air, for the reception of smells, and may be dilated in proportion to the quantity of inhaled air, and again contracted, when it is expelled in the same abundance.

The air, therefore, filled with the subtle and invisible effluvia of bodies, consisting of their volatile, oily, and saline particles, is, by the powers of respiration, urged through the nose, so as to apply the said particles to the almost naked and constantly soft olfactory nerves, in which a kind of feeling is excited, which we call *smelling*: and by this sense we distinguish the several kinds of oils, salts, and other matters, difficultly reducible to classes, which hereby we perceive indistinctly; whence they are difficultly recalled to memory, though the odours already established are sufficient enough for our purposes. This sense serves to admonish us of any pernicious putrefaction; of any violent acrimony; or of a mild, soapy, and useful disposition in bodies. And as salt, joined with an oil, is the object of taste; so a volatile oil, aided with salts, serves to excite smells: whence the affinity of the two senses, which conjunctly assist and move each other, may be easily understood. But volatile particles chiefly are distinguished by smell, and fixed ones by the taste; perhaps because the thick mucous cuticle, spread over the tongue, intercepts the action of the more subtle saline effluvia from acting upon the taste, which yet easily affect the softer and less covered nerves of the internal nose. We are ignorant of the reason why some smells please, and others displease; perhaps custom may have some effect in this case.

Smells have a very strong action, but of short continuance; because they are applied immediately, by the most minute particles, to nerves which are very near to the brain itself, and almost naked; from thence too proceeds the force of poisonous vapours, and the refreshment from agreeable odours, by which some persons

sensations are effectually recalled to themselves out of a dead swoon, or even after drowning. From hence comes that violent sneezing, which often arises from acrid particles; and a looseness or purging of the bowels, from the smell of some medicines, with the power of particular antipathies. From hence is derived the pernicious effects of excessive sneezing, more especially blindness, from the near consent or society of the nerves. But amongst the various parts of the nose, the septum, and more especially the os turbinatum, have a considerable share in the organ of smelling: since these are parts multiplied in quick scented animals, so as to form beautiful spires in hounds and other quadrupeds; and in fish, who smell by water, they are formed like the teeth of a comb, in an elegant manner,

SECT. IV. *The E A R.*

The ear in general. Every one knows that the ears are two in number, that they are situated in the lateral parts of the head, and that they are the organs of hearing. Anatomists commonly divide or distinguish the ear into external and internal. By the external ear they mean all that lies without the external orifice of the meatus auditorius in the os temporis; by the internal ear, all that lies within the cavities of that bone, and also the parts that bear any relation thereto.

The greatest part of the external ear consists of a large cartilage very artificially framed, which is the basis of all the other parts of which this portion of the ear is made up. The internal ear consists chiefly of several bony pieces, partly formed in the substance of the os temporis, and especially in that portion of it called *apophysis petrosa*; and partly separated from, but contained in a particular cavity of, that bone.

The

The external ear. Two portions are distinguished in the external ear; one large and solid, called *pinna*, which is the superior, and by much the greater part; the other small and soft, called the *lobe*, which makes the lower part. We may likewise consider two sides in the outward ear; one turned obliquely forward, and irregularly concave; the other turned obliquely backward, and unequally convex; for all ears which have not been disordered by binding the head too tight in childhood, are naturally bent forward.

The foreside is divided into eminences and cavities. The eminences are four in number, called *helix*, *antihelix*, *tragus*, and *antitragus*. The *helix* is the large folded border or circumference of the great portion of the ear. The *antihelix* is the large oblong eminence or rising surrounded by the *helix*. The *tragus* is the small anterior protuberance below the anterior extremity of the *helix*, which in an advanced age is covered with hairs. The *antitragus* is the posterior tubercle, below the inferior extremity of the *antihelix*.

The cavities on the foreside are four in number: the hollow of the *helix*; the depression at the superior extremity of the *antihelix*, called *fossa navicularis*; the *concha*, or great double cavity that lies under the rising termed *antihelix*, the upper bottom of which is distinguished from the lower by a continuation of the *helix* in form of a transverse *crista*; and lastly, the *meatus* of the external ear, situated at the lower part of the bottom of the *concha*.

The backside of the external ear shows only one considerable eminence, which is a portion of the convex side of the *concha*, the other portion being hid by the adhesion of the ear to the *os temporis*. This adhesion hinders us likewise from seeing the hollow answering to the *crista*, by which the cavity of the *concha* is divided.

The

The other parts of the external ear are ligaments, muscles, integuments, sebaceous and ceruminous glands, vessels, and nerves.

The cartilage of the outward ear is nearly of the same extent and figure with the large solid portion thereof already mentioned; but it is not of the same thickness, being covered by integuments on both sides. In the lobe or soft lower portion of the ear, this cartilage is wanting. On the back side, it shows all the eminences and cavities on the fore side in an opposite situation with respect to each other, except the fold of the great circumference; and it consists only of one piece from that circumference all the way to the meatus externus, except at the two extremities of the folded part of the helix, where there are two small separate portions connected to the great cartilage only by the integuments.

The cartilaginous portion of the external meatus auditorius does not make a complete circle; but rather a short tube, in one side of which there is a break, and which terminates in an oblique border fixed to the edge of the bony canal by several small inequalities; and from this obliquity it is, that the cartilaginous border terminates downward in a kind of apex or point. The lateral break in this cartilage is between the upper and back part of its circumference; and on each side thereof the cartilaginous edges are rounded. There are likewise two or three other small incisures in this circumference, which, in regard to the meatus, represent obliquely transverse fissures. The anterior fissure is in a manner quadrangular; neither are the intermediate parts always opposite to each other, for the uppermost is a little further from the os temporis than the posterior.

The external ear is fixed to the cranium, not only by the cartilaginous portion of the meatus already mentioned, but also by ligaments which are two in number,

ber, one anterior, the other posterior. The anterior ligament is fixed by one extremity to the root of the apophysis zygomatica of the os temporis, at the anterior and a little toward the superior part of the meatus ossæus, close to the corner of the glenoid cavity; and by the other extremity, to the anterior and superior part of the cartilaginous meatus.

The posterior ligament is fixed by one end to the root of the mastoid apophysis, and by the other to the posterior part of the convexity of the concha; so that it is opposite to the anterior ligament. There is likewise a kind of superior ligament, which seems to be only a continuation of the aponeurosis of the frontal and occipital muscles.

Of the muscles of the external ear, some go between the cartilages and the os temporis, others are confined to the cartilages alone. Both kinds vary in different subjects, and are sometimes so very thin as to look more like ligaments than muscles. The muscles of the first kind are generally three in number, one superior, one posterior, and one anterior; and they are all very thin.

The small muscles which are confined to the cartilages, are only small strata of fibres found on both sides of the cartilages. In many subjects they are of so pale a colour as not to look at all like muscular fibres. Of this number are those which Valsalva discovered in the different cavities on the backside of the cartilage; and those found by Santorini on the tragus, and along the convex part of the anterior portion of the helix. (See the Treatise on the Muscles.)

The skin of the external ear is in general a continuation of that which covers the neighbouring parts of the temporal region. The skin on the fore side of the ear is accompanied by a very small quantity of cellular substance; and therefore we find all the eminences and cavities of that side distinctly marked upon it, as far

as the bottom of the external meatus auditorius. In what has been said of the skin, the epidermis is likewise comprehended.

The backside is covered by the skin continued from the fore-side; but as the folds are there very close, it only passes over them, except that portion of the concha which surrounds the entry of the meatus auditorius, and which is joined to the os temporis by means of the cellular substance. The hollow of that common fold which lies between the antihelix and concha does not appear on the backside; for as it is filled with cellular substance, the skin passes over it.

The lobe of the ear, or that soft portion which lies under the tragus, antitragus, and meatus auditorius, is made up of nothing but skin and cellular substance. The meatus auditorius is partly bony and partly cartilaginous. The bony portion is the longest, and forms the bottom of the canal, as may be seen in the description of the skeleton. The cartilaginous portion is the shortest; and, in adults, forms the external opening or orifice of the canal, as has been already said.

These two portions joined endwise to each other, form a canal of a considerable length, of different wideness in its different parts, and a little contorted. It is lined on the inside by the skin and cellular membrane, through its whole length; and thus these integuments make up for the breaks in the cartilaginous portions, and form a kind of cutaneous tube in the other portion. The cellular membrane is confounded with the perichondrium and periosteum of the meatus.

The skin which covers both sides of the cartilage contains a great number of small glands, which continually discharge an oily, whitish humour, collected chiefly near the adhesions of the ear to the head, and under the fold of the helix; and these glands are of the sebaceous kind. The skin, which lines the meatus auditorius, contains another kind of glands, of a yellowish colour, and which may be plainly seen on

the convex side of the cutaneous tube already mentioned.

These glands are disposed in such a manner as to leave reticular spaces between them, and they penetrate a little way into the substance of the skin. They are called *glandulae ceruminosae*, because they discharge that matter which is named *cerumen* or the *wax* of the ear. They were first described by Steno, though some have named them after Duveney.

The inner surface of the cutaneous tube is full of fine hairs, between which lie the orifices of the ceruminous glands. The first place in which we meet with these glands is on that part of the convex side of the cutaneous tube, which supplies the breaks of the cartilaginous meatus.

The arteries of the external ear come anteriorly from the *arteria temporalis*, and posteriorly from the *occipitalis*, all of which are branches of the external carotid. It is proper to observe here, that the occipital artery communicates with the *vertebralis*, and thereby with the internal carotid. The veins are rami of the *jugularis externa*; and the occipital vein, one of these rami, communicates, not only with the *vena vertebralis*, but with the neighbouring lateral sinus of the *dura mater*.

The *portio dura* of the auditory nerve having passed out of the cranium through the *foramen stylo-mastoidum*, in the manner that shall be afterwards described, gives off a ramus, which runs up behind the ear, to the backside of which it sends several filaments; and the trunk of this ramus sends likewise filaments to the meatus and foreside of the ear. The second vertebral pair sends also a ramus to the ear, the ramifications of which communicate with those of the other ramus from the *portio dura*.

After having described the external parts of the ear, we next proceed to examine its internal bony parts; and here we shall consider them at some length, as they

they are purposely omitted in the osteological part of this work.

The bony part of the organ of hearing may be divided into four general parts: 1. The meatus auditorius externus; 2. The tympanum; 3. The labyrinth; 4. The meatus auditorius internus. It may likewise be divided into immoveable or containing parts, which take in all the four already mentioned; and moveable or contained parts, which are four little bones lodged in the tympanum, called *incus*, *malleus*, *stapes*, and *os orbiculare* or *lenticulare*.

The meatus externus at its outer end has its edges rough and prominent; but its back part is considerably depressed. The passage itself is somewhat more than half an inch in length, running obliquely from behind foreward in a curved direction. Its cavity is almost oval, but wider at each end than in the middle. It terminates inwardly by an even circular edge, lying in a plane very much inclined, the upper part of it being turned outward, and the inner part inward; so that the canal is longer on the lower than upper side. The circular edge is grooved quite round for the attachment of the *membrana tympani*.

In children, this bony canal is wanting, as well as the mastoid process; and the inner circular edge is a distinct ring, which, in an advanced age, unites entirely, and becomes one piece with the rest. It is termed the *bony circle* in infants; and indeed it is very easily separated from all the other parts.

It would seem, therefore, that the whole bony canal in adults is only a prolongation of the bony circle in children; because, even in a more advanced age, the whole canal may without much difficulty be taken out. The circular groove lies between the mastoid process and the articular fissure mentioned in the description of the other parts of the temporal bone.

Tympanum. The tympanum, or drum of the ear, is a cavity somewhat spherical, or rather hemispherical,

cal, the bottom of which is turned inward, and the mouth joined to the circular groove already mentioned.

The remarkable eminences are three in number: A large tuberosity, lying in the very bottom of the tympanum, a little toward the back part; and a small irregular pyramid, situated above the tuberosity, and a little more backward, the apex of which is perforated by a small hole: on one side of the basis two small bony filaments are often found in a parallel situation; and indeed it appears that they are seldom wanting, though their tender structure exposes them to be often broken. In the third eminence is a cavity situated at the upper and a little toward the anterior part of the bottom of the tympanum. This cavity is part of a half canal, which in a natural state has one of the muscles of the malleus lodged in it.

The principal cavities in the tympanum, are, The opening of the mastoid cells; the opening of the Eustachian tube; the bony half canal; the fenestra ovalis and rotunda; and to these may be added the small hole in the pyramid.

The opening of the mastoid cells is at the posterior and upper part of the edge of the tympanum. The cells themselves which end there are hollowed out in the substance of the mastoid process, being very irregular and full of windings and turnings.

The openings of the Eustachian tube is at the anterior and upper part of the edge of the tympanum. It runs from the tympanum toward the posterior openings of the nostrils and arch of the palate. The bony portion thereof, of which alone we here speak, is hollowed out in the pars petrosa, and is afterwards lengthened out by the spinal process of the os sphenoides.

The mastoid cells, and the Eustachian tube, from their situation, may be looked upon in some measure as prolongations of the tympanum.

The bony half canal lies immediately above the Eustachian tube, toward the upper side of the pars petroso. In the recent subject, one of the muscles of the malleus is lodged in it,

The fenestra ovalis is a hole of communication between the tympanum and labyrinth. It lies immediately above the tuberosity; the upper side of it being a little rounded, the lower a little flattened, and has its longest diameter from before backwards. Toward the labyrinth, this opening has a little boarder round it, which renders it narrower at that place than any where else.

The fenestra rotunda is something less than the ovalis, and situated above it toward the lower and posterior part of a large tuberosity; the opening of it, which is the orifice of a particular duct in the labyrinth, lying obliquely backward and outward.

The hole in the apex of the pyramid is the orifice of a cavity, which may be named the *sinus* of this pyramid.

Officula auditus. The tympanum contains several little bones, called the *bones of the ear*. They are generally four in number, demonstrated from something to which they are said to bear a resemblance, viz. incus, malleus, stapes, and os orbiculare or lenticulare.

Incus. The incus, or anvil, resembles, in some measure, one of the anterior dentes molares, with its roots at a great distance from each other. It may be divided into a body, and two branches or legs; one of the legs is long, the other short. The body is turned forward, the short leg backward, and the long leg downward.

The body of the incus is broader than it is thick. It has two eminences, and two cavities between them, much in the same manner as we see in the crown of the first dentes molares.

The short leg is thick at its origin; and from thence de-

decreasing gradually, it ends in a point. It is situated horizontally, its point being turned backward, and joined to the edge of the mastoid opening of the tympanum.

The long leg viewed through the external auditory passage appears to be situated vertically; but if we look upon it either on the fore or back side, we see it is inclined, the extremity of it being turned much more inward than the root or origin. The point of the extremity is a little flattened, bent inward like a hook, and sometimes a little hollowed like a kind of ear-picker. By this we may distinguish the incus of one ear from that of the other, when out of their places: for turning the short leg backward, and the long leg downward, if the curvature of this long leg be toward the left hand, the bone belongs to the right ear; if toward the right, it belongs to the left ear.

Malleus. The malleus, or hammer, is a long bone with a large head, a small neck, an handle, and two processes; one in the neck, the other in the handle.

The top of the head is considerably rounded; and from thence it contracts all the way to the neck. Both head and neck are in an inclined situation; and the eminences and cavities of it answer to those in the body of the incus. The handle is looked upon by some as one of the processes of the malleus; and in that case it is the greatest of the three. It forms an angle with the neck and head: near which it is something broad and flat, and decreases gradually toward its extremity.

The process of the handle, termed by others the *small* or *short process* of the malleus, terminates in the angle already mentioned, being extended toward the neck, and lying in a straight line with that side or border of the handle which is next it. The process of the neck, called also *processus gracilis*, is, in a natural state, very long; but so slender, that it is very easily broken,

especially when dry; which is the reason why the true length of it was for a long time unknown. It arises from the neck, and sometimes appears much longer than it really is, by the addition of a small dried tendon sticking to it.

When the malleus is in its true situation, the head and neck are turned upward and inward; the handle downward, parallel to the long leg of the incus, but more forward; the process of the handle upward and outward, near the superior portion of the edge of the tympanum, near the centre of which is the extremity of the handle; and the process gracilis forward, reaching all the way to the articular fissure in the os temporis. It is easy, after what has been said, to distinguish the malleus of the right side from that of the left.

Stapes. The stapes is a small bone, very well denominated from the resemblance it bears to a stirrup. It is divided into the head, legs, and basis. The head is placed upon a short flattened neck; the top of which is also sometimes flat, sometimes a little hollow.

The two legs, taken together, form an arch like that of a stirrup; in the concave side of which is a groove which runs through their whole length. One leg is longer, more bent, and a little broader than the other. The basis resembles that of a stirrup both in its oval shape and union with the legs, but it is not perforated. Round its circumference next the legs, is a little border, which makes that side of the basis appear a little hollow. The other side is pretty smooth; and one half of the circumference is more curved than the other.

The subject being in an erect posture, the stapes is to be considered as lying on its side, with the head turned outward near the extremity of the leg of the incus; the basis being fixed in the fenestra ovalis; the longest leg backward, and both legs in the same plane.

By

By this situation, it is easy to know the stapes belonging to each ear.

Os orbiculare. The os orbiculare, or lenticular bone, is the smallest bone in the body. It lies between the head of the stapes and extremity of the long leg of the incus, being articulated with each of these.

In dry bones it is found very closely connected, sometimes to the stapes, sometimes to the incus; and might, in that state, be easily mistaken for an epiphysis of either of these bones.

These four little bones appear to have been unknown to the Greek anatomists. It is difficult to say with certainty who has discovered them; but Vesalius is the first who has named the malleus and incus; Arantius or Sylvius, the os orbiculare; Ingratias is said to have discovered the stapes.

Labyrinth. The labyrinth is divided into three parts; the anterior, middle and posterior. The middle portion is termed *vestibulum*, the anterior *cochlea*, and the posterior *labyrinth in particular*; which comprehends the three semicircular canals.

The cochlea lies forward and inward toward the extremity of the pars petrosa; the semicircular canals backward and outward toward the basis of the process; and the vestibulum between the other two.

Vestibulum. The vestibulum is an irregular round cavity, less than the tympanum, and situated more inward, and a little more forward. These two cavities are in a manner set back to back, with a common partition between them, perforated in the middle by the fenestra ovalis, by which the cavities communicate with each other. The cavity of the vestibulum is likewise perforated by several other holes; on the back side by the five orifices of the semicircular canals; on the lower part of the fore side by a hole, which is one of the passages of the cochlea; and on the fore side, toward the meatus auditorius, opposite to the fenestra ovalis, by a number of very small holes, for the pas-

sage of the nerves; on the upper side there are only small pores.

Semicircular canals. The semicircular canals are only three in number; one vertical, one oblique, and one horizontal; or by some they are called *vertical superior*, *vertical posterior*, and *horizontal or external*. The vertical canal is situated transversely with respect to the pars petrosa, the convex side of it being turned upward. The oblique canal lies farther back than the former, and runs parallel to the length of the process, the convex side being turned backward, with one extremity upward, the other downward: the superior extremity of this canal meets and loses itself in the internal extremity of the former.

The curvature and extremities of the horizontal canal are almost on a level; the curvature lying obliquely backward; and the extremities forward, and under those of the vertical canal, but a little nearer each other, the inner being almost in the middle space between the extremities of the oblique canal.

The horizontal canal is generally the least of the three; the oblique is often, and the vertical sometimes, the greatest; and sometimes these two are equal. All the three canals are larger than a semicircle, forming nearly three-fourths of one; they are broader at the orifices than in the middle. These orifices open into the back-side of the vestibulum, and are but five in number, because two of them open into each other; so that in the posterior part of the vestibulum, two appear toward the inside, and three toward the outside.

In children, the substance of these canals is compact, while that which surrounds them is spongy. Hence they may be easily separated from the rest of the pars petrosa. In adults, all the parts of the bone are so solid, that these canals appear only like passages formed in a piece of ivory. From this description, it is easy to distinguish the right labyrinth from the left.

Cochlea,

Cochlea. The cochlea is a sort of spiral body with two ducts, formed in the anterior part of the pars petrosa, somewhat resembling the shell of a snail. The parts to be distinguished in it, in its true situation, are, The basis; the apex; the spiral lamina, or half septum, by which its cavity is divided into two half canals; the modiolus, round which the cochlea turns; and, lastly, the orifices and union of the two ducts. The basis is turned directly inward toward the internal foramen auditorium, the apex outward; and the axis of the modiolus is nearly horizontal; but in all of them allowance must be made for the obliquity of the pars petrosa in which they lie.

The basis of the cochlea is gently hollowed; and, toward the middle, perforated by several small holes. The modiolus is a kind of short cone with a very large basis, which is the middle of the basis of the cochlea: through its whole length runs a double spiral groove, which, through a microscope, shows a great number of pores. The cochlea makes about two turns and a half from the basis to the apex; and the two half canals being firmly united together through their whole course, form a half septum, called *lamina spiralis*; which must not be confounded with the complete septum in the recent subject, as is often done. One edge of the lamina spiralis is strongly joined to the modiolus, being thicker there than in any other place; whereas the other edge is terminated all round by a very thin border, lying in the middle cavity of the cochlea. In the natural state, the other half of the septum is membranous, and completes the partition between the two canals. The two half canals turn jointly about the modiolus; one being situated toward the basis of the cochlea, the other toward the apex; for which reason we have always called one of them *internal*, the other *external*.

The spiral or volute of the cochlea begins at the lower part of the vestibule; runs from thence forward

to the top, then backward down to the bottom, afterward upward and forward; and so on from the basis, which is turned inward to the apex, which is turned outward. From this description, it is easy to know to what ear any cochlea belongs when we see it prepared: it likewise teaches us, that, in the right cochlea, the direction of the turnings is the same as in garden-snails, and almost all the other common shells; but in the left cochlea, the turnings are in a contrary direction, as in one kind of shell, which is rarely met with. The two half canals communicate fully at the apex of the cochlea. Their separate openings are toward the basis; one of them being immediately into the lower part of the fore-side of the vestibulum, the other into the fenestra rotunda. These two openings are separated by a particular turning, which shall be described afterwards.

The *meatus auditorius internus*, is on the back-side of the pars petrosa, in some measure behind the vestibule and basis of the cochlea. It is a kind of blind hole, divided into two fossulæ; one large, the other small. The large one lies lowest, and serves for the portio mollis of the auditory nerve or seventh pair. The small one is uppermost, and is the opening of a small duct, through which the portio dura of the same nerve passes. The inferior fossula is full of little holes, which, in the natural state, are filled with nervous filaments of the portio mollis, which go to the vestibule, to the semicircular canals, and to those of the cochlea. It is this fossula which forms the shallow cavity at the basis of the spindle of the cochlea. The passage for the portio dura of the auditory nerve runs behind the tympanum, and its external orifice is termed *foramen stylo-mastoideum*. It begins by the small fossula, and pierces from within outward the upper part of the pars petrosa, making there an angle or curvature; from thence it is inclined backward behind the small pyramid of the tympanum, and runs down to the foramen stylo-mastoi-

maстоideum; through which it goes out, and is distributed in the manner to be described hereafter. It communicates likewise by a hole with the sinus of the pyramid, and lower down by another hole with the tympanum. At the upper part of the pars petrosa it is covered with a bony lamina, although sometimes it has been found open above.

The soft parts of the internal ear are chiefly the membrana tympani, the periotseum of the tympanum, and of the ossicula auditus, labyrinth, and of all its cavities, the membrana mastoidæa interna, the muscles of the ossicula, the parts which complete the formation of the Eustachian tube, the arteries, veins, and nerves. We are, however, under a necessity of beginning by the tuba Eustachiana, for two reasons: first, because the bony parts of that tube are but of very small use for the knowledge of its whole structure and composition; and, secondly, because we are obliged to mention it in describing the muscles.

The *ductus auris palatinus*, or Eustachian tube, as was observed in the description of the skeleton, is a canal or duct which goes from the tympanum to the posterior openings of the nares, or nasal fossæ, and toward the arch of the palate; it is dug in the apophysis petrosa along the carotid canal, and it is lengthened out by the spinal apophysis of the os sphenoidale.

In its natural state, this duct reaches from the cavity of the tympanum to the root or superior part of the internal ala of the apophysis pterygoides; and through this whole course it is made up of two portions, one entirely bony, and the other partly bony, partly cartilaginous, and partly membranous.

The bony portion lies through its whole length immediately above the fissure of the glenoide or articular cavity of the os temporis, and terminates at the meeting of the spinal apophysis of the os sphenoides with the pars petrosa of the os temporis.

The

The other or mixed portion reaches in the same direction from this place to the internal ala of the apophysis pterygoides, or to the posterior and outer edge of the nares. But to form a more exact idea of it, it will be proper to consider it as divided into four parts, two superior and two inferior.

The two upper parts or quarters are bony ; and of these the innermost is formed by the side of the apophysis petrosa, the outermost by the side of the apophysis spinalis of the os sphenoides. Of the two inferior parts, the internal, or that next the os sphenoides, is cartilaginous ; and the external, or that next the pars petrosa, membranous.

The Eustachian tube thus formed, is very narrow next the ear, but grows gradually wider, especially near the posterior nares, where the inner cartilaginous side terminates by a prominent edge, and the outer side joins that of the neighbouring nostril. The cavity of the tube is lined by a membrane like that of the internal nares, of which it appears to be a continuation ; and on the prominent edge, this membrane is considerably increased in thickness, representing a kind of half pad.

The situation of the two tubes is oblique, their posterior extremities at the ears being at a greater distance than the anterior at the nares ; and the convex sides of the prominent edges are turned toward each other. The openings of the tubes are oval at this place ; as is likewise their whole cavity, especially that of the mixed portion.

The membrana tympani is a thin, transparent, flattish pellicle ; the edge of which is round, and strongly fixed in the orbicular groove which divides the bony meatus of the external ear from the tympanum or barrel. This membrane is very much stretched or very tense, and yet not perfectly flat : for on the side next the meatus externus it has a small hollowness, which is pointed on the

the middle ; and on the side next the tympanum, it is gently convex, and also pointed in the middle.

This membrane is situated obliquely, the upper part of its circumference being turned outward, and the lower part inward, suitably to the direction of the bony groove already mentioned. It is made up of several very fine laminæ, closely united together. The external lamina is in some measure a production of the skin and cuticula of the external meatus ; for they may be pulled at the same time like the finger of a glove. The internal lamina is a continuation of the periosteum of the tympanum ; and when the membrane has been first macerated in water, each of these lamina may be subdivided into several others. In very young children, this membrane is covered on the outside by a thick mucilaginous web.

The depression in the middle of the membrana tympani, is caused by the adhesion of the malleus ; the handle of which is closely joined to the inside of the membrane, from the upper part of the circumference all the way to the centre, to which the end of the handle is fixed. This handle seems to lie in a very fine membranous duplicature ; by means of which it is tied to the membrana tympani, and which serves it for a periosteum. The malleus is accompanied with blood-vessels, which run in a radiated manner from the centre to the circumference of the membrane ; but these are best seen in the foetus.

The periosteum of the tympanum, or barrel of the ear, produces that of the small bones ; and it may be made visible by means of anatomical injections, which discover capillary vessels very distinctly ramified on the surface of the ossicula. It is likewise continued over the two fenestræ, and enters the Eustachian tube, where it is lost in the inner membrane of that duct.

The cellulæ mastoidæi are very irregular cavities in the substance of the mastoide apophysis, which communicate

municate with each other, and have a common opening towards the inside, and a little above the posterior edge of the orbicular groove. These cells are lined by a fine membrane; which is partly a continuation of the periosteum of the tympanum, and partly seems to be of a follicular structure like a kind of membrana pituitaria. The mastoide opening is opposite to the small opening of the Eustachian tube, but a little higher.

The ligaments of the ossicula may be looked upon as continuations of the periosteum. The incus is tied by a strong short ligament fixed in the point of the short leg to the edge of the mastoide opening. Between the incus and malleus we find a small thin cartilage. The malleus is connected through the whole length of its handle to the inside of the membrana tympani, in the manner already said.

The malleus has two little muscles, one anterior, and one internal; and the stapes has one muscle. See Innes on the muscles.

The internal muscle of the malleus, called *tensor tympani*, is very fleshy and distinct. It lies along the inside of the Eustachian tube, and is inserted in the neck of the malleus above the small apophysis, advancing likewise as far as the handle. Vesalius first observed, and afterwards Eustachius more particularly described, this muscle.

The anterior muscle of the malleus, called, from its use, *laxator tympani*, is said by some to be fleshy, long, and thin. It runs along the outside of the Eustachian tube, to which it adheres very closely through its whole length, and is inserted in the long thin apophysis of the malleus. It is partly accompanied by a nerve, which forms what is called the *chorda tympani*, as we shall see hereafter. Haller denies the existence of muscular fibres in this substance. Sabatier describes it; but doubts if it be really muscular. Cæcilius Foliis is said to have been the discoverer.

A third muscle has by some been described under the

the name of *external* or *superior muscle of the malleus*; but this is much less distinct than those already mentioned. It is said to arise from the internal superior and posterior part of the meatus externus, and to be fixed by a small tendon to the neck of the malleus. Neither Haller nor Sebatier have been able to discover muscular fibres in it. Casserius first described it.

The muscle of the stapes is short and thick, and lies concealed within the small bony pyramid at the bottom of the tympanum. It runs forward to be inserted in the neck of the stapes on the side of the longest and most crooked leg of that bone.

The three parts of the labyrinth, that is, the vestibulum, semicircular canals, and cochlea, are lined by a fine periostrum, which is continued over all the sides of their cavities, and shuts the two fenestræ of the tympanum. Upon this the vessels and nerves are dispersed.

The semicircular canals are simply lined by a periostrum adhering to their inner surfaces without any particular membranous bands. The two half-canals of the cochlea are lined in this manner; the periostrum of the two sides of the bony spiral lamina advances beyond the edge of that lamina, and forms a membranous duplicature, which extending to the opposite side completes the spiral septum.

The septum separates the two half canals from the basis to the apex; but there it leaves a small opening, by which the small extremities of the half canals communicate with each other. The large extremity of the external half canal ends by an oblique turn in the fenestra rotunda, which is shut by a continuation of the periostrum of that canal. The large extremity of the other half-canal opens into the vestibulum; and these two extremities are entirely separated by a continuation of the periostrum.

The whole internal cavity of the labyrinth is filled with a watery fluid secreted from the vessels, which are
dispersed

disperfed upon the periofteum. This fluid tranfmits to the nerves the vibrations it receives from the membrane fituated between the tympanum and labyrinth.

The fuperfluous part of this fluid is fuppofed to pafs off through two fmall canals called the *aquæducts of Cotunnus*, from the discoverer, an ingenious phyfician at Naples. One of thefe ducts is fent off from the cochlea, at the under part of the fcala tympani, near the feneftra rotunda; it terminates by a pretty wide triangular opening within the cranium, under the meatus internus. The beginning of this duct was known to Duverney, Caffeböhm, and Morgagni; but they confidered it as a paffage for an artery and a vein. It is lined internally with the dura mater, which is connected with the periofteum of the cochlea. The other duct goes off under the termination of the common canal in the veftible. The orifice of this was firft difcovered by Caffeböhm, and afterwards by Morgagni, who has defcribed it; but is unacquainted with its ufe. From this place the duct afcends, and terminates by a triangular opening between the layers of the dura mater, at the back part of the pars petrofa, under the middle of its upper edge. It is alfo lined by a production of the dura mater, which may be traced to the veftible. For a full account of the above, fee an excellent Differtation by Dr Meckel of Berlin.

All the periofteum of the internal ear, efpecially that of the officula and tympanum, is in children no more than a mucilage; and in them likewise the membrana tympani is thick, opaque, and covered with a whitifh, flimy mater.

Through the whole extent of the periofteum of the internal ear, efpecially on that of the officula, femicircular canals, and half-canals of the cochlea, we difcover a vaft number of blood-veffels, not only by anatomical injections, but in inflammations, and even without the help of a microfcope. The arteries come partly from the internal and external carotids, and partly from the arteria basilaris, which is a continuation of the verte-

1

bralis,

bralis, the small capillary ramifications of which may be observed to accompany the auditory nerve through the internal foramen auditorium, from whence the fluid is supposed to be absorbed. Two veins carry the principal part of the blood from the labyrinth; one goes off from the cochlea, near its aqueduct, and ends in the lateral sinus; the other lies near the aqueduct of the vestibule, and carries the blood from that cavity, and from the semicircular canals, into the beginning of the internal jugular vein, by a triangular opening.

The portio mollis of the auditory nerve ends, by its trunk, at the great fossula of the internal auditory hole, from whence the filaments pass through several small holes in the basis of the cochlea, to be distributed thro' the cochlea, the vestibule, and the semicircular canals. See Monro on the Nervous System, Tab. XXIX. XXX. XXXI.

The portio dura runs first of all into the small fossula of the foramen auditorium internum, then passes through the whole bony duct called *aquæductus Fallopii*, and comes out again through the stylo-mastoide hole of the os temporis. In this course it communicates with the dura mater on the upper or anterior side of the apophysis petrosa, at the place where the bony duct is interrupted.

Having reached behind the small pyramid in the bottom of the tympanum, this nerve sends a small filament to the muscle of the stapes; and a little before it goes out by the stylo-mastoide hole, it gives off another more considerable filament, which enters the tympanum from behind forward, passes between the long leg of the incus and handle of the malleus, and afterwards runs cross the whole breadth of the tympanum a little obliquely, and goes out at the same place at which the tendon of the anterior muscle of the malleus enters.

This small nerve is generally called *chorda tympani*, because in its passage through the tympanum it has been compared to the cord of a drum. Having left the cavity of the internal ear, it advances toward one side of
the

the basis of the tongue, where having joined the nervus lingualis of the fifth pair, it is considered as a kind of recurrent; but the remaining part of its course must be referred to the description of the tongue.

The portio dura of the auditory nerve having passed through the foramen stylo-mastoideum, is distributed in the manner to be afterwards mentioned in the description of the nerves; and we ought very carefully to observe its different communications with the branches and rami of the nerves of the fifth pair, with the sympathicus medius or eighth pair, with the second pair of cervical nerves, and with the nervi sub-occipitales or tenth pair of the medulla oblongata, &c.

Hearing. As the sense of hearing perceives the elastic tremors or impulsions of the air, so we observe the sensitive organ of the ear to be composed in a different manner from that of any of the other senses; as it is made up for the most part either of hard bones or elastic cartilages and membranes, which are the most exquisitely enabled to receive and communicate the necessary tremors.

The external parts of this organ, called the *auricle* or *outer ear*, is a cartilaginous funnel connected; but with a sort of mobility before and behind, to the bones of the temple, by means of a strong cellular plate, and likewise by its own proper ligaments and muscles; but the mobility of this part is diminished by custom. This cartilage is of a very compound figure; in general of a kind of oval figure, yet marked with spirals standing up, and hollows interposed, to which other hollows and ridges correspond in the opposite surface.

This whole cartilaginous body of the outer ear is only surrounded by a thin skin, and an empty cellular substance; it is replenished with many sebaceous glands, which supply an ointment. This part is governed or directed by certain muscles, which generally lose their use and action, from the custom of binding the head in children, which we are otherwise to suppose they

they were designed by nature to perform. And they act likewise upon the concha; the cavity of which they doubtless are designed to open or enlarge.

To the concha is connected the *meatus auditorius*, and through the auditory passage are continued the cuticle and true skin, gradually extenuated and exactly stretched over the surface of the bone, by which it is rendered extremely sensible of any itching pleasure or pain; and, being replenished with irritable hairs, is by them admonished of any sordes or wax abounding, and guarding from the entrance of small insects. But under the skin are seated the *glandulæ ceruminosæ*, which pour out their contents by short ducts into the cavity of the auditory passage; at first of an oily consistence, but afterwards it becomes more thick, bitter, and inflammable like wax. This liniment defends the sensible skin and membrane of the tympanum from injuries of the air, and keeps out or catches any small insects; but, when accumulated in too great abundance in those who are slothful or uncleanly, it may be the cause of deafness, or a difficulty of hearing.

Into this funnel of the ear the sonorous waves of the air flow, which, from principles of mechanics, it must of course collect together. The elastic air only receives sonorous tremors or impulsions; and transfers them, either alone or principally, much after the same manner as we see water, without air, transfer any impulse that is given to it; for that water conveys sound, and seemingly nearly in the same time as the atmosphere, is proved by different experiments. (See Monro on the structure and physiology of fishes.) The sound is increased in air that is condensed, and is lost in a vessel emptied of its air. But the medium receives these tremors, either from some body striking against it, or from the air itself colliding against another body, or lastly from the collision of two bodies against each other in the air. But the body which produces sound ought to tremble or vibrate in all, even the least of its particles,

so as to form alternate arches rising up from the former straight surface, and returning beyond the same; the curve line of the same exceeding that of the sounding body. From such a tremor, the contiguous air is beat into waves, whereby the parts of the air that lie outermost are compressed and fly back again as soon as their elasticity gets over the impulse; whence the air flies again towards the sonorous body, where it is now more loose and rarefied, to be there again compressed by impulsion; and in the same manner the anterior and outer portion of air, surrounding that which is impelled, is, by the action of the latter, compressed and removed farther from the trembling body, yet so as to return again in its proper time by the force of elasticity, driving its contents to the tremulous body for the exciting of a new wave. These oscillations or impulsions of the air are required to succeed each other with a certain velocity; and, in order to render them audible, they must not be fewer than 30 in a second of time.

Acute sounds are, in general, yielded from bodies that are hard, brittle, and violently shook or struck; but grave sounds are from the contrary. Those sounds in general are called *acute*, which are produced from more numerous tremors in an equal time; and those *obtuse*, which are produced from few tremors. As to any medium betwixt acute and grave sounds, there is none but what is arbitrary. Cords, or other bodies, that yield the same number of vibrations in a given time, are said to be *unison*; as those which make double the number of oscillations in that time, are said to yield a tone that is an octave or eight notes higher; and other proportions betwixt the numbers of the vibrations have different names assigned to them. The shorter cords produce sharper tones, and the reverse, in a proportion directly as their lengths; as those which are more stretched afford sharper sounds in a subduplicate proportion to their tenuity, or to the weights or powers by which they are stretched. Experiments to this purpose

pose are very easily made with a monochord, or a series of cords stretched with weights.

The sound, thus produced, whether acute or grave, strong or weak, is carried through the air with a celerity equal to about 1142 feet in a second, or near 13 miles in a minute; and that with an uniform velocity, without abating in the larger distances. But a contrary wind, causing the vibrations to extend more slowly, retards the progression of sound about 1-12th of its velocity. So likewise density and dryness of the air increase the sound, as a rarefaction and moisture of the air lessen it. Hence, in summer time, sounds move swifter; and in Guinea, it has been observed to pass at the rate of 1098 Parisian feet in one second of time.

The sound, thus every way extended, meets with certain particles in all adjacent bodies, even in water and mercury, to which it communicates similar tremors or vibrations, not only such as are in unison with the original tone, and which yield a sound in a more particular manner sensible; but also it excites tremors less sensibly, even in the other parts of bodies, which vibrate in the various proportions of the scale. From hence it is, that every sound which we hear, is a mixture of the original tone, produced by the trembling body, in conjunction with secondary tones generated from the elastic tremors of the surrounding bodies. The strength of sound is increased, if one audible or primary tone follows the other so closely, that their succession cannot be distinguished by the ear; but if they follow each other so slowly as to be distinguishable by the ear, they produce an echo; but to produce this requires an interval of six thirds of a second of time, or the distance of 55 feet betwixt the reflecting or echoing body and the ear.

Sounds, being elastic, are reflected from hard bodies in angles equal to those of their incidence. But the same sound, ushered into the open air, and dilating through an immense sphere, grows proportionably

weaker : but if it be ushered through a tube, in a cylindrical shape, the strength of it is more confined together ; or else, by being collected into the focus of a parabola or ellipsis, it becomes increased, as we observe in speaking-trumpets, from which the voice goes out parallel to the focus of the parabola, without scattering the sonorous rays.

Therefore the sonorous waves of the elastic air, being driven into the cartilaginous funnel of our ear, which is naturally inclined forward and outward in an high situation, are repelled and collected together, by alternate reflections from its elastic sides, into the cavity of the concha, from whence it proceeds through the auditory, with a force so much stronger as the surface of the outer ear is larger than the light or section of the auditory passage. Through this passage, however cylindrical, the same force is continued entire forward, and increased by new resonances, excited from the percussion of the lastic cartilages and hard bones, so as to mix imperceptibly with the primitive sound.

Moreover, the bottom or end of the said auditory passage is terminated internally by the *membrana tympani*; which Dr Haller says is not naturally perforated with any opening, as far as he has been able to discover ; and that the transmission of smoke is fabulous. Authors in general agree with him now in the former of these opinions ; but that an accidental opening has sometimes happened, and that the smoke of tobacco has been blown through it during life, is certain. Upon the surface of this membrane, and more especially upon its conical cavity pointing inward, the sonorous waves strike, after they have received their last reflections from the auditory passage, by which the elastic fabric of this membrane is forced into oscillation.

The membrane is stretched over the *tympanum*; which contains the little bones to which the small muscles of the internal ear are fixed. By means of the tensor of the malleus, the membrane of the tympanum is disposed for the hearing of weak sounds ; as
the

the other muscle serves to moderate in too violent sounds, by drawing the malleus from the incus; by which therefore the propagation of the sonorous tremors is interrupted. If the membrane of the tympanum be broke, or the bones of hearing dislocated, the person becomes at first hard of hearing, and afterwards, says Dr Haller, perfectly deaf. There have been instances, however, where the membrana tympani has been partly destroyed, and yet the person has retained the sense of hearing, though less distinctly than before.

The malleus returns the tremors impressed upon the membrane of the tympanum to the incus, which sends it inwards to the next bones.

The *stapes*, aptly enough so called from its figure, lies inclined, and is covered by its own muscle, which seems to draw the stapes, that it may lie higher up, under the back part of the fenestra ovalis, and pass out of it before. Thus the nervous pulp of the vestibulum is pressed by the basis of the stapes, and by the air of the tympanum, and the *Eustachian tube*, by the action of the circumjacent muscles, may be compressed and closed, and probably a little relaxed and opened again, by the circumflex muscle of the moveable palate. By this canal the inspired air enters into the tympanum to be changed or renewed, and the surrounding mucus of the little bones and other parts are this way deposited: nor is it at all improbable, that the air enters by this tube, to support the tympanum when it is pressed inward by the more violent sounds; for sounds themselves, received into the mouth, are this way conveyed to the organ of hearing. In inspiration, the air presses the membrane of the tympanum outward: and from thence proceeds that clashing or whispering noise, by which the hearing is obscured, when the mouth is held wide open in yawning; for then the air entering more abundantly through the cavity of the tube, to the tympanum, resists the tremors of the external air.

With respect to the nerve which is distributed thro'

the vestibulum and semicircular canals, there is no doubt but it is struck by the tremors of the external air, propagated to the stapes; from whence the tremors immediately pass through the oval fenestra, to press upon the naked pulp of the nerve; and it is probable, that the spiral plate of the cochlea, spread full of nerves, is agitated with tremors from the oscillations of the membrane of the tympanum, by which the air in the cavity of the tympanum is agitated, so as to press the membrane of the round fenestra, which again agitates the air contained in the cochlea.

The preceding conjecture is plausible; since the spiral plates make up a triangle, ending in a short point towards the tip, by which it may be conceived to contain an infinite number of nervous cords, continually shortening in their length; and by that means adapted to an harmonical unison or consonance, according to the variety of acute and grave sounds, so as to tremble together at the same time with most of them; namely, the longest cords in the basis of the cochlea with grave sounds; and the shortest cords nearer the tip or apex, with the sharper sounds. Whether are sounds perceived in the middle semicircular canals, when these alone are found in all classes of animals? Are they detained in these canals, in the cochlea, and by the membrane suspended through the vestibulum? This seems probably the case.

From what has been said, it appears, that the elastic waves or tremors of the air arrive through the outer ear and auditory passage, to the membrane of the tympanum; which being injured, and not repaired, the hearing is in a great measure destroyed. This seems to be stretched, for hearing weak sounds, by the muscles of the malleus. From this membrane the sound is conveyed through the small bones to the vestibulum; for these bones being destroyed, the hearing is again abolished. The bony sides of the vestibulum, by their tremulation, agitate the small quantity of aqueous fluid surrounding

surrounding the nervous pulp. It seems to be struck by the nervous pulp suspended in the vestibulum, and that tremor to be continued through the continuous pulp of the cochlea and semicircular canals. Of more than this we are not certain: but, by undoubted experiments, tremors, and even elastic sounds, communicate themselves by the internal Eustachian tube, and through all the bones of the skull, so as to impress their force upon the auditory nerve.

The distinction of sounds, doubtless, proceeds from the celerity of the tremors excited in the hearing nerve, according as they succeed each other more swiftly or slowly, in a short time; in order to which it is not necessary the mind should number them; it is sufficient that she perceive their numbers to be different, and that this difference excites a variation in her thoughts and ideas thence arising. Whether the harmony or agreeableness of sounds arises from the number of parts sounding together in unison? and whether the mind, ignorant of herself, numbers the degrees of consonance, so as to please herself in a majority of them? these are questions denied by the most expert musicians, who make it appear, that there is an agreeableness, and that very considerable, in sounds approaching the least to a consonance, and which lies in a proportion very difficult to determine. Why do sounds often become too sharp for the ear? Our auditory nerves seem to be strained upon the spiral plates, in such degrees as to be in danger of breaking, after the manner drinking-glasses may be broke by sharp sounds, and as the hearing is sometimes almost lost for a while by the violently shrill whistlings of the inhabitants of the Canary islands.

SECT. V. *The M O U T H, &c.*

Introduction. THE word *mouth* may have two significations: for, first, it means the transverse slit between

the nose and chin, formed by the lips; and, secondly, it expresses the internal cavity, of which this transverse slit is the external opening. For this reason the mouth may be distinguished into external and internal; and the parts of which it consists may likewise come under the same two general heads. The bony parts are the *ossa maxillaria*, *ossa palati*, *maxilla inferior*, and the teeth: to these we may add the *os hyoides*, and the upper *vertebræ* of the neck.

The external parts of the mouth are, The two lips, one upper, the other under; the borders or red parts of the lips; the corners or commissures of the lips; the fossula of the upper lip, the basis of the under lip; the chin; the basis of the chin; the skin; the beard; and even the cheeks, as being the lateral parts of the mouth in general, and of the lips in particular.

The internal parts of the mouth are, The gums palate, *septum palati*, *uvula*, *amygdalæ*, the tongue, the membrane which lines the whole cavity of the mouth, the salival ducts and glands, and the bottom of the mouth. We might likewise reckon among the internal parts of the mouth, all the muscles that have any relation to it, as those of the lips, of the tongue, of the *uvula*, of the *septum palati*, &c. and to these might be added the muscles of the lower jaw, and of the *os hyoides*.

§ 1. *The Cheeks, Lips, and Gums.*

THE cheeks and lips form the sides and entry of the cavity of the mouth. They are formed in general by the connection of several fleshy portions of different breadths, fixed round the convex sides of the two jaws, covered on the outside with the skin and fat, and lined on the inside by a glandulous membrane. Besides all this, the lips seem likewise to have a soft spongy substance in their composition, which swells and subsides on certain occasions, independently of the action of the

the muscles belonging to them, and is mixed with fat.

The substance which forms the red border of the lips is very different from the rest of the skin, being a collection of very fine, long, villous papillæ, closely connected together, and covered by a fine membrane, which seems to be both a continuation of the epidermis, and of that pellicle which covers the glandulous membrane of the cavity of the mouth. This substance is extremely sensible, and very painful when the outer membrane is by any accident destroyed. The internal membrane of the upper lip forms a small middle frænum above the first dentes incisorii.

The gums are that reddish substance which covers the two sides of the whole alveolar border of both jaws, insinuates itself between all the teeth, surrounds the collar of each tooth in particular, and adheres very strongly to them. Therefore the outer and inner gums are continuous, and both together form just as many openings as there are teeth.

The substance of the gums is of a very singular structure, resembling, in some measure, the texture of a hat, supposed to be very compact and elastic. It is not immediately fixed to the bones of the jaws, but by the intervention of the periosteum, with which it is perfectly united; and it is covered by a fine strong even membrane, which sticks very close to the substance of the gums; and seems to be a continuation of that thin membrane which goes to the lips and cheeks, and of that which goes to the tongue.

The arteries which go to the lips, cheeks, and gums, are ramifications of the external carotid, and chiefly of those branches called *maxillares externæ et internæ*. The veins are ramifications of the external jugular.

The nerves of these parts come from the maxillaris superior and inferior, which are branches of the fifth pair; and also from the portio dura of the auditory nerve,

nerve, or sympatheticus minimus; the ramifications of which are spread in great numbers on all these parts, and communicate in a pretty singular manner with the nerves of the fifth pair in several places, as may be seen in the Description of the Nerves.

The muscles of the lips are commonly divided into common and proper. The common muscles are those which end at the angles or commissures of the two lips; and those are proper which are fixed in one lip only; which are again subdivided into the proper muscles of the upper lip, and proper muscles of the under lip. All these muscles have particular names; some of which are taken from something in the conformation of the muscles, some from the insertions or situation, and some from the uses attributed to them, as has been already described.

The muscles may be enumerated in the following order: Levator anguli oris; levator labii superioris, alæque nasi; depressor labii superioris, alæque nasi; depressor anguli oris; depressor labii inferioris; levator labii inferioris; buccinator; zygomaticus major; zygomaticus minor, orbicularis oris. See Vol. I.

The common muscles of the lips either draw both corners of the mouth at once, or only one at a time, according to the different direction of their fibres. The proper muscles pull the different parts of the lips in which they are inserted. The buccinators in particular may serve to move the food in mastication. An entire treatise might be written on the almost innumerable combinations of the different motions of all these muscles, according to the different passions, and according to the different postures in which a man may put his face. None are more affecting than those produced by the cutanei alone, especially in weeping, which they do by their adhesions to the depressors of the corners of the mouth, &c. But by their insertions in the bone of the lower jaw, they draw up the lower part of the integuments of the neck, and those of the breast

breast next to these ; for they cannot move the jaw. In old people, and in those who are very much emaciated, these muscles may be perceived by the eye, under the chin, and on the neck.

§ 2. *The Palate, Uvula, &c.*

THE palate is that arch or cavity of the mouth, surrounded anteriorly by the alveolar edge and teeth of the upper jaw, and reaching from thence to the great opening of the pharynx. The arch is partly solid and immoveable, and partly soft and moveable. The solid portion is that which is bounded by the teeth, being formed by the two ossa maxillaria and two ossa palati. The soft portion lies behind the other, and runs backward like a veil fixed to the edge of the ossa palati, being formed partly by the common membrane of the whole arch, and partly by several muscular fasciculi, &c.

The membrane that covers all this cavity is continued with the membrane of the nares upon the inner surface of the pharynx. It is very thick set with small glands, known under the name of *palatine*, the orifices of which are not so sensible as in the pharynx, and especially in the rugæ of the superior portion thereof, where M. Heister observed a considerable orifice, and a canal proportioned to that orifice, which he could easily inflate with air. Small ducts of the same kind with what has now been mentioned, may be supposed to lie along the middle line or raphe of the arch of the palate, and along the alveolar edge, because of some small tubercles or points which appear there.

This membrane, together with that of the posterior nares, forms, by an uninterrupted continuation, the anterior and posterior surface of the soft portion of the palate or velum palati, so that the muscular fasciculi of
this

this portion lie in the duplicature of a glandulous membrane.

The velum or valvula palati, terminates below by a loose floating edge, representing an arch situated transversely above the basis or root of the tongue. The highest portion or top of this arch sustains a small, soft, and irregularly conical glandular body, fixed by its basis to the arch, and its apex hanging down without adhering to any thing, which is called *uvula*.

On each side of the uvula there are two muscular half arches, called *columnæ septi palati*. They are all joined to the uvula by their upper extremities, and disposed in such a manner as that the lower extremities of the two which lie on the same side, are at a little distance from each other, and so as that one half arch is anterior, the other posterior, an oblong triangular space being left between them, the apex of which is turned toward the basis of the uvula.

The two half arches on one side, by joining the like half arches on the other side, form the entire arch of the edge of the septum. The posterior half-arches run by their upper extremities, more directly toward the uvula than the anterior. The anterior half-arches have a continuation with the sides of the basis of the tongue, and the posterior with the sides of the pharynx. At the lower part of the space left between the lateral half-arches on the same side, two glands are situated, termed *amygdalæ*, which shall be described hereafter, together with the glandular structure of the uvula, among the other glands of the mouth.

The half-arches are chiefly made up of several flat fleshy portions, almost in the same manner with the body of the septum. The membrane which covers them is thinner than the other parts of it towards the palate, pharynx, and tongue. Each portion is a distinct muscle, the greatest part of which terminates by one extremity in the substance of the septum and of the

the half-arches, and by the other extremity in parts different from these.

As anatomists used formerly to ascribe all these muscles, as far as they knew them, to the uvula, without any regard to the septum, they termed them in general either *ptery-staphylini*, or *peri-staphylini*. The last part of these two compound words expresses the uvula: the first part of the first word is an abridgement of *ptery-goides*, and expresses the insertion of these muscles; but the first part of the second word signifies no more than round, or about, &c.

We might make use of the term *peri-staphylinus* as a general denomination for the muscles belonging to the septum, and then add the other terms, of which these names have been made up by modern writers. But the reader will find it more agreeable to use the names expressed in the treatise on the muscles already described.

Of the muscles of the palati we have found the *constrictores isthmi*, *faucium*, *palato pharyngei*, *tenfores palati*, *levatores palati*, and *azygos uvuvæ*.

The septum palati serves to conduct the lacrymal lymph, and that which is continually collected on the arch of the palate, into the pharynx. It serves for a valve to hinder what we swallow, and especially what we drink, from returning from the nares.

§ 3. *The Tongue.*

EVERY one knows, that the tongue is a soft fleshy body, which fills all that part of the cavity of the mouth that is surrounded by the alveolar border and teeth of the lower jaw, and extends still farther back. All this space is therefore in a manner the mould and measure of the length and breadth of the tongue, as well as of its thickness and figure.

The tongue is divided into the basis and point; the upper and under sides; and the lateral portions, or edges

edges. The basis is the posterior and thickest part; the point, the anterior and thinnest part. The upper side is not quite flat, but a little convex; and divided into two lateral halves, by a shallow depressed line, called *linea linguae mediana*. The edges are thinner than the other parts, and a little rounded as well as the point. The lower side reaches only from the middle of the length of the tongue to the point.

The tongue is principally composed of very soft fleshy fibres, intermixed with a particular medullary substance, and disposed in various manners. Many of these fibres are confined to the tongue without going any farther; the rest form separate muscles which go out from it in different ways, and are inserted in other parts. All the upper side of the tongue is covered by a thick membrane of a papillary texture, upon which lies another very fine membrane like a kind of epidermis, which is likewise continued over the lower side, but without papillæ. Under the epidermis, on the surface of the tongue, we find the corpus mucosum thicker but more moist than in other parts of the body. This disposition seems necessary to protect the tender papillæ, which are the organs of taste. In brute animals a perforated mucous net-work receive the papillæ, which are in a manner wrapped up in capsules of this mucous body covered with the cuticle.

Three sorts of papillæ may be distinguished in the upper side of the tongue; capitatae, semi-lenticulares, and villosæ. Those of the first kind are the largest, and are of a lenticular form, having round heads with short stems. They lie on the basis of the tongue in small superficial fossulæ.

They have a small depression in the middle of their upper or convex side, which opens into a mucous follicle. They occupy the whole surface of the basis of the tongue, and they are situated near each other in such a manner as that the most anterior form an angle. They are glandular papillæ, or small salival or

muci-

mucilaginous glands, of the same kind with those that are to be described hereafter.

We commonly observe about the middle of this part of the tongue a particular hole of different depths, the inner surface of which is entirely glandular, and filled with small papillæ, like those of the first kind. It is called *foramen cæcum Morgagnii*, as being first described by that author. It is nothing else than the meeting of excretory ducts of glands situated in the tongue, and which throw out a thick saliva.

The papillæ of the second kind, or semilenticulares, are small orbicular eminences, only a little convex, their circular edge not being separate from the surface of the tongue. When we examine them in a sound tongue, with a good microscope, we find their convex sides full of small holes or pores, like the end of a thimble.

They lie chiefly in the middle and anterior portions of the tongue; and are sometimes most visible on the edges, where they appear to be very smooth and polished even to the naked eye, and sometimes in living subjects. They soon lose their consistence after death; so that, by rubbing them several times, they may be drawn out in form of small soft pyramids inclined to one side.

The papillæ of the third kind, or villosæ, are the smallest and most numerous. They fill the whole surface of the upper side of the tongue, and even the interstices between the other papillæ. They would be more properly named *papillæ conicæ* than *villosæ*, from the figure which they appear to have when examined through a microscope in clear water. They are naturally softish, but they become extremely flaccid after death; so that by handling them they may be made short and thick, whereas they are naturally long and small. Anatomists consider these as the extremities of the vessels and nerves of the tongue.

The fleshy fibres of which the tongue is composed,
and

and which go no further than the tongue, may be termed *musculi linguæ interiores*. The fibres these muscles consist of, are of three general kinds; longitudinal, transverse, and vertical; and each of these situations admits of different degrees of obliquity. The longitudinal fibres point to the basis and apex of the tongue; and seem partly to be expansions of the *musculi stylo-glossi*, *hyo-glossi*, *genio-glossi*, and *lingualis*. The vertical fibres seem likewise to be in part produced by these muscles.

Besides these mixed productions, there is a distinct plane of longitudinal fibres, which run near the surface of the upper side of the tongue, and a distinct transverse plane under them. All these fibres are partly interwoven, one portion of them terminating at the two edges of the tongue, and the other at the basis and point, without going to any other part; and they lie immediately above those that belong to the *genio-glossi*. To discover all these different fibres, and their different degrees of direction, we need only cut the tongue longitudinally, after it has been boiled, or long macerated in strong vinegar.

The *musculi exteriores*, are those which by one extremity make a part of the body of the tongue, and are fixed by the other in some part without the tongue. Of these we commonly reckon three pairs; *stylo-glossi*, *hyo-glossi*, *genio-glossi*.

The muscles which move the *os hyoides* belong likewise to the tongue. The names of these are, *Mylo-hyoidæi*, *genio-hyoidæi*, *stylo-hyoidæi*, *omo-hyoidæi*, *sterno-hyoidæi*.

When either of the *stylo-glossi* acts, it turns the tongue toward the cheek, and forces the aliment between the upper and lower molares. When they act jointly with the lateral portions of the superior fleshy plane of the tongue, they turn the tongue obliquely upward to the teeth of the upper jaw, and near the cheeks, as when we bring down any part of the food that may

have stuck there after mastication. When they act jointly with the lateral portions of the hyo-glossi, they turn the tongue downward between the lower teeth and the cheek.

When all the parts of the hyo-glossi act together, they shorten the tongue. They likewise turn the point of the tongue between the teeth and the under lip, and make it pass over that lip. The superior fleshy plane of the body of the tongue bends it upward toward the palate, and makes it pass along and lick the upper lip.

The tongue is fixed in the mouth, not only by muscles, but also by ligaments, which are for the most part membranous. The principal ligament is that called the *frænum*, which is the prominent fold that appears first under the tongue when we raise it, with the mouth opened; and is no more than a continuation or loose duplicature of that membrane which covers the inferior cavity of the mouth. It covers the curvature of the anterior portion of the genio-glossi from the point of the tongue, almost as high as the middle interstice between the lower dentes incisarii.

The other ligaments of the tongue are the small membranous fold which runs along the middle of the convex side of the epiglottis to the basis of the tongue, and the membranous folds which cover the inferior half arches of the septum palati. These three folds are continuations of the membrane which covers the neighbouring parts. The aponeurotic ligaments of the stylo-glossus may be looked upon as true lateral ligaments of the tongue; and they adhere a little to the lower part of the musculus pterygoidæus internus or anterior.

The principal blood-vessels of the tongue are those that appear so plainly on its lower surface on each side of the *frænum*; and they consist of one artery and one vein, which accompany each other, and are called *arteriæ et venæ sublinguales* or *raninæ*. The veins lie next the *frænum*, and the arteries on the other side of the

veins. The arteries are rami of the second internal or anterior branch of the external carotid on each side, and communicate with the first external or posterior branch of the same carotid, &c. The veins are commonly rami of a branch of the external jugular vein, described among the other veins.

We observe six nervous ropes to go very distinctly to the basis of the tongue, and to continue their course through its whole substance all the way to the point. Two of these ropes are rami of the inferior maxillary nerves, or of the third branch of the fifth pair; other two are the nerves of the ninth pair; and the remaining two are small portions, or the first branches of the eighth pair.

The great lingual nerve on each side runs forward between the musculus mylo-hyoidæus and hyo-glossus, under the genio-glossus, and is distributed to the fleshy fibres all the way to the point of the tongue, communicating by several small filaments with the lingualis minor, and with the nerve from the eighth pair. For the other distributions of it, we refer to the description of the nerves.

The small lingual nerve on each side goes off from the maxillaris inferior, sometimes at, and sometimes before, its passage between the pterygoide muscles. Afterwards, separating more and more from the trunk, it passes under the lateral part of the tongue, over the sublingual gland; of which hereafter. It supplies the nearest parts of the tongue as it passes; and then entering its substance, terminates at the point, having sent a great number of filaments to the papillary membrane. It communicates, as has been said, with the lingualis major, and with the nerve from the eighth pair.

This lingual nerve, a little after it leaves the maxillaris inferior, receives the chorda tympani, which was formerly mentioned in describing the ear.

This small nervous rope has been looked upon by
anato-

anatomists as a kind of small recurrent of the nervus lingualis; but as in some subjects it appears to make simply an acute angle with the lingual nerve, and as this lingual nerve is something larger after this angle, it ought rather to be believed to come from the tympanum, and to unite with the lingual nerve, than to arise from this nerve, and run up to the tympanum. In some subjects, the union of this nerve with the lingualis is in a manner plexiform, and very difficult to be unfolded.

The lingual nerve of the eighth pair, which is its first branch, runs first of all on the inside of the digastric muscle of the lower jaw, and supplies the geniohyoidæi, the neighbouring muscles of the basis of the tongue, and those of the pharynx. Afterwards it sends out the ramifications, and forms the communications described in the history of the nerves; and lastly goes to the lower part of the tongue, where it communicates with the lingual ramus of the fifth pair, and with the lingual ramus of the ninth.

The tongue is the organ of the sense called the *taste*; and by certain experiments it appears, that the power of taste is exercised by the tongue chiefly, although it is not confined to the tongue alone. For on whatever part of the mouth, palate, or cheeks, we apply a sapid body, we do not perceive the sense of pain, but of taste; and of some bodies, as arum, pepper, &c. it will be stronger and more distinct in these parts than any where else. That sensation which is sometimes excited in the stomach, œsophagus, and fauces, by the regurgitation of the aliments, seems also to belong to the tongue, to which the sapid vapours are sent back, uncommonly acrid and penetrating; and even that sense which is sometimes occasioned in the stomach, œsophagus, and fauces, from a rising of the aliments, seems also to be owing to the tongue, to which the tastable vapours are conveyed.

Only the upper and lateral edges of the tongue are fitted to exercise the sense of taste.

The *papillæ* of the tongue, which are larger and softer than those of the skin, perpetually moist, perform the office of touch more exquisitely than those of the small and dry cutaneous papillæ; and from hence the tongue is liable to a sharper degree of pain: moreover, naked salts are not otherwise perceived than under a sense of moisture, or of pain. But the papillæ of the tongue being raised a little protuberant, to perform the office of taste, from salts dissolved in water, or saliva, and applied against their tips or summits, are affected in a particular manner; which being distinguished by the mind, and referred to certain classes, are called *tastes*, either sour, sweet, rough, bitter, saline, urinous, spirituous, aromatic, or pungent and acrid, of various kinds, insipid, putrid, and others resulting partly from pure salts, and in part from an intermixture of the subtle, animal, or vegetable oils, variously compounding and changing each other. If it be inquired, Whether the diversity of tastes arises from the different figures which are natural to salts? and whether this does not appear from the cubical figure in which sea-salt shoots, the prismatical figure of nitre, or the particular configuration of vitriol, sugar, &c.? we answer, That this does not seem probable, for even tasteless crystals have their particular configurations; and the taste arising from very different salts, and differently qualified objects of this sense, are too much alike each other, and at the same time too inconstant or changeable, to allow such a theory; as for example, in nitre. The mechanical reason, therefore, of the diversity of tastes, seems to reside in the intrinsic fabric or opposition of their elements, which do not fall under the scrutiny of our senses.

But the nature or disposition of the covering with which the papillæ are clothed, together with that of the juices, and of the aliments lodged in the stomach, have

have a considerable share in determining the sense of taste; insomuch, that the same flavour does not equally please or affect the organ in all ages alike, nor in persons of all temperatures; nor even in one and the same person at different times, who shall be differently accustomed in health or variously diseased. In general, whatever contains less salt than the saliva itself seems insipid.

The spirituous parts, more especially of vegetables, either penetrate into the papillæ themselves, or else are absorbed by the adjacent villi of the tongue; as may appear from the speedy restitution of the strength by vinous or aromatic liquors of this kind, even before they are received into the stomach.

Nature designed the difference of tastes to be felt by the tongue, that we might know and distinguish such foods as are most salutary: for in general, there is not any one kind of aliment healthy that is of a disagreeable taste; nor are there any ill tasted matters that are fit for our nourishment. For it must be observed, that we here take no notice of excess, by which the most healthy food may be prejudicial. In this manner, nature has invited us to take necessary food, as well by the pain called hunger as by the pleasure arising from the sense of taste. But brute animals, who have not, like ourselves, the advantage of learning from each other by instruction, have the faculty of distinguishing flavours more accurately, by which they are admonished to abstain cautiously from poisonous or unhealthy food; and therefore it is that herbivorous cattle, to which a great diversity of noxious plants is offered amongst their food, are furnished with such large and long papillæ, of so elegant a structure, in the tongue, which are not so necessary to man.

The tongue is likewise one of the principal instruments of speech, and of the articulation of the voice. Riolan, in his *Anthropographia*, mentions a child of

five years of age, who, though he had lost his tongue by the small-pox, but not the uvula, continued still to speak almost as distinctly as before. Probably the basis of the tongue still remained. M. de Jussieu has published an observation in the Memoirs of the Royal Academy concerning a little girl who could speak, though she was born without a tongue; in room of which there was only a kind of small tubercle.

The tongue serves also to collect all the morsels which we chew; to turn them in different manners, and to different parts of the mouth; and to rub off whatever sticks to the palate: and it is useful in spitting, sucking, &c. It bears a great part in deglutition, being assisted by the digastric muscles; which, by contracting at the same time that the other muscles press the lower jaw against the upper, raise the os hyoides, and fix it at a convenient height; that the stylo-glossi and hyo-glossi may make the basis of the tongue bear back upon the morsel which is to be swallowed, and so force it into the pharynx; the portions of which, that are at that time immediately above the morsel, do instantly contract, and push it into the œsophagus.

§ 4. *The larynx.*

THE larynx forms the protuberance in the upper and anterior part of the neck, called commonly *pomum Adami*. This is larger and more prominent in men than in women.

It is chiefly made up of five cartilages; the names of which are these: Cartilago-thyroides, which is the anterior and largest; cricoides, the inferior, and basis of the rest; two arytenoides, the posterior and smallest; and the epiglottis, which is above all the rest. These cartilages are connected together by ligaments, and they have likewise muscles, glands, membranes, &c. belonging to them.

Cartilago thyroidæa. The cartilago thyroidæa is large
and

and broad, and folded in such a manner as to have a longitudinal convexity on the fore-side, and two lateral portions which may be termed *alæ*. The upper part of its anterior middle portion is formed into an angular notch; the upper edge of each ala makes an arch; and, together with the middle notch, these two edges resemble the upper part of an ace of hearts in playing cards.

The lower edge of each ala is more even, and the posterior edges of both are very smooth, being lengthened out both above and below by apophyses, which we name the *cornua of the thyroide cartilage*. The superior apophyses are longer than the inferior, and the extremities of all the four are rounded like small heads, which in the inferior apophyses have a shining surface on the inside, resembling an articular eminence.

On the outside of each ala near the edge, is a prominent oblique line which runs from behind forward. The upper extremity of this line is near the superior apophysis or cornu; and both that and the lower extremity end in a small tuberosity, the lowest being often the most considerable. These tuberosities serve for the insertion of muscles and ligaments. The inside of the *alæ* and the convex side of the anterior portion are very uniform; and this cartilage ossifies gradually in old age.

Cartilago cricoides. The cricoide cartilage resembles a kind of thick, irregular ring, very broad on one side and narrow on the other; or it may be compared to a small portion of a thick tube, cut horizontally at one end, and very obliquely at the other, and distinguished into a basis and top, into an anterior, posterior, and two lateral sides. The basis is almost horizontal when we stand, and to this the *aspera arteria* is connected; so that the cricoides may be looked upon as the upper extremity of the trachea.

The posterior portion of the cricoides is larger than the rest, and its posterior or convex side is divided by

a longitudinal eminence, or prominent line, into two distinct surfaces, for the insertion of muscles. The top is gently sloped above this prominent line; and terminates on each side by a kind of obtuse angle, formed between it and the oblique edge of each lateral portion of this cartilage. At the upper part of each of these angles, there is a very smooth articular surface, gently convex.

The whole posterior side is distinguished into two lateral portions by two prominent lines, each of which runs down almost in a straight direction from the articular surface at the top, a little below the middle of this side, where it terminates in another articular line a little concave; and near these four articular surfaces there are small tubercles. The two superior surfaces are for the articulation of the cartilagine arytеноидææ, and the two inferior, for the articulation of the inferior cornua or appendices of the cartilago thyroïdes.

Cartilagine arytеноидææ. The cartilagine arytеноидææ are two small, equal, similar cartilages, which joined together resemble the spout of an ewer; and they are situated on the top of the cricoides. In each, we may consider the basis; cornua; two sides, one posterior and concave, the other anterior and convex; and two edges, one internal, the other external, which is very oblique. The bases are broad and thick; and have each a concave articular surface, by which they are joined to the cricoides.

The cornua are bent backward, and a little toward each other. In some subjects they are very loose, appearing like true appendices, and easily separable from the rest. Between their inner edges they form a kind of fissure, and their outer oblique edges terminate each by a thick prominent angle.

Epiglottis. The epiglottis is an elastic cartilage, somewhat of the figure of the tongue, narrow and thick at the lower part, thin and slightly rounded at the upper part, gently convex on the fore-side, and
concave

concave on the back-side. It is situated above the anterior or convex portion of the cartilago thyroides; and its lower extremity is tied by a short, pretty broad, and very strong ligament, to the middle notch in the upper edge of that cartilage. It is perforated by a great number of small holes, which are hid by the membranes that cover its two sides.

Ligaments of the larynx. The cartilago thyroides is connected to the cricoides by several short strong ligaments, round the articulations of the two inferior cornua with the lateral articular surfaces of the cricoides. The apices of the superior cornua are fixed to the posterior extremities of the great cornua of the os hyoides, by slender round ligaments, about a quarter of an inch in length.

In the middle of each of these ligaments, we often meet with a small cartilage of an oval figure, and much thicker than the ligaments. The thyroides is likewise connected to the os hyoides by a short, broad, strong ligament; one end of which is inserted in the superior notch of the cartilage, and the other in the lower edge of the basis of the bone. It has also two ligaments at the middle of the concave side which belong to the arytenoidææ.

The cricoides is tied to the lower part of the thyroides by a strong ligament; and by the ligaments already mentioned, to the inferior cornua of that cartilage. Its basis is fixed to the first cartilaginous ring of the trachea arteria, by a ligament exactly like those by which the other rings are connected together; and the membranous or posterior portion of the trachea is likewise fixed to the posterior part of the basis of the cricoides.

Glottis. The cartilagine arytenoidææ are connected to the cricoides by ligaments, which surround their articulations with the top of that cartilage. Anteriorly the basis of each arytenoides is fixed to one end of a ligamentary cord, which by its other end is inserted about the middle of the concave side of the anterior portion

portion of the thyroides. At their insertions in the thyroides, these two ligaments touch each other; but a small space is left between them, where they are fixed in the two arytenoides; and they seem likewise to have a small adhesion to the top of the cricoides. This is what is called *the glottis*.

Under these two ligamentary cords there are two others which run likewise from behind forward. The interstice between the superior and inferior cords on each side form a transverse fissure, which is the opening of a small membranous bag, the bottom of which is turned outward, that is, toward the ala of the thyroides. These two sacculi are the ventricles mentioned by the ancients, and restored by M. Morgagni, who has given an excellent description of them. They are chiefly formed by a continuation of the internal membrane of the larynx, and the inner surface of their bottom appears sometimes to be glandular.

On the anterior surface of the arytenoid cartilages, there is a small depression between the basis and the convex upper part. This depression is filled by a glandular body, which not only covers the anterior surface of each arytenoides, but is likewise extended forward from the basis over the posterior extremity of the neighbouring ligamentary cord. They are larger and more sensible in some subjects than in others; and they are covered by the membrane which lines the neighbouring parts. These glands were discovered by M. Morgagni.

The two ligaments which connect the epiglottis to the notch of the thyroid cartilage, and to the basis of the os hyoides, and a third which ties the basis of the os hyoides to the notch of the thyroides, form a triangular space filled with a cellular or fatty substance, and with small glands.

The epiglottis has likewise two lateral ligaments, by which it is connected to the arytenoides all the way to their points or cornua. It has also a membranous li-

gament,

gament, which, running along the middle of its anterior or concave side, ties it to the root or basis of the tongue. This ligament is only a duplicature of the membrane which covers the epiglottis, continued to the neighbouring parts. Lastly, there are two lateral membranous ligaments belonging to it, fixed near the glandulous bodies called *amygdalæ*.

The epiglottis is not only perforated by the regular holes already mentioned, but has likewise a great number of small irregular fissures and breaks, which are so many different lacunæ situated between its two membranes, and filled with small glands, the excretory orifices of which are chiefly on the back-side of this cartilage.

Muscles of the larynx. The larynx gives insertion to a great number of muscles, which may be divided into common, proper, and collateral. The common muscles, according to the general acceptation of that term, are all those that move the whole body of the larynx, one extremity of them being inserted in other parts; and these are reckoned to be four in number, two for each side, viz. sterno-thyroidæi, thyro-hyoidæi or hyo-thyroidæi.

The proper muscles are those inserted wholly in the larynx, and which move the cartilages separately. These have been divided in various manners, but may be all reduced to the following pairs: Crico-thyroidæi; crico-arytenoidæi laterales; crico-arytenoidæi posteriores; thyro-arytenoidæi; arytenoidæi; thyro-epiglottici; aryteno-epiglottici.

By the collateral muscles, is understood those which are inserted by one portion in the larynx, without appearing to contribute any thing to the motions of it. Of this kind are the thyro-pharyngæi, crico-pharyngæi, &c.

The larynx may likewise be moved by muscles, which are not immediately inserted in it, but altogether in other parts. Such are the mylo-hyoidæi, genio-hyoidæi,

dæi, stylo-hyoidæi, omo-hyoidæi, sterno-hyoidæi, and especially the digastrici of the lower jaw, by reason of their particular adhesion to the os hyoides. It is likewise probable that those muscles of the pharynx which are inserted in the basis cranii, may, in certain circumstances, move the larynx in some small degree. The blood vessels of the larynx, &c. are the arteriæ and venæ, thyroideæ, superiores, and inferiores. The nerves are the superior and inferior laryngeals, which are branches of the eighth pair.

Uses. The larynx serves particularly to admit and let out the matter of respiration; and the solidity of the pieces of which it is composed, hinders not only external objects, but also any hard thing which we swallow, from disordering this passage. The glottis being a narrow slit, modifies the air which we breathe; and as it is very easily dilated and contracted, it forms the different tones of the voice, chiefly by means of the different muscles inserted in the cartilagine arytеноидææ, to which the other muscles of the larynx, both proper and common, are assistants.

The whole larynx is likewise of use in deglutition, as has been already observed, by means of its connection with the os hyoides, to which the digastric muscles of the lower jaw adhere; which muscles raise the larynx together with the os hyoides every time we swallow.

The facility of varying and changing the tone of the voice depends on the flexibility of the cartilages of the larynx, and decreases in proportion as we advance in age; because these cartilages gradually harden and ossify, though not equally soon in all persons: and this change happens not only in the cartilago thyroides, but also to the cricoides and arytеноides.

The musculi sterno-thyroidæi serve in general to pull down the thyroide cartilage, and the whole larynx along with it. They may likewise assist the sterno-hyoidæi in its action, and compress the thyroide gland; of which hereafter. The thyro-hyoidæi may, as oc-
casion

caſion requires, either draw up the larynx toward the os-hyoides, or draw that bone downward toward the cartilago-thyroides.

It is difficult to determine the uſe of the crico-thyroidæi from their ſituation. They may either pull the cricoides obliquely backward, or the thyroides obliquely forward; and by this action the inferior cornua of the thyroides, and ſmall articular ſurfaces of the cricoides, muſt ſlide upon each other.

Both the lateral and poſterior crico-arytenoidæi may ſeparate the arytenoide cartilages, and thereby open or dilate the glottis; but they do not both perform this action in the ſame manner. The lateral muſcles ſeparate theſe cartilages obliquely forward, and at the ſame time looſen or relax the ſides of the glottis; but the poſterior muſcles ſeparate them obliquely backward, and at the ſame time ſtretch or extend the ſides of the glottis; and when both muſcles act equally, they ſeparate the cartilages directly.

The thyro-arytenoidæi acting together, draw both the arytenoide cartilages forward, and conſequently looſen the glottis, and render it capable of the ſmalleſt quaverings of the voice. They may likewiſe probably compr'eſs the lateral ſinufes or ventricles of the larynx, and alſo the arytenoide glands.

The arytenoidæi bring the arytenoide cartilages cloſe together, and preſs them againſt each other; and when the cartilages are in this ſituation, they may at the ſame time be inclined either forward by the thyro-arytenoidæi, or backward by the crico-arytenoidæi poſteriores. By this means the glottis, when ſhut, may be either relaxed or tenſe; and in this laſt caſe it is entirely ſhut, as when we hold in our breath in ſtraining: but of this more in another place.

The general uſe of the epiglottis is to cover the glottis like a pent-houſe, and thereby hinder any thing from falling into it when we eat or drink; and for this purpoſe it is depreſſed in the manner that ſhall be ſhown hereafter.

hereafter. It serves likewise to hinder the air which we inspire from rushing directly upon the glottis; but by splitting it, as it were, obliges it to enter by the sides, or in an oblique course. The muscles of the epiglottis do not appear to be absolutely necessary for that cartilage; for in deglutition it may be sufficiently depressed by the basis of the tongue, and it may raise itself again by its own elasticity. The thyro-epiglottici and aryteno-epiglottici may serve to shut any lateral openings that might remain when the epiglottis is depressed by the basis of the tongue; and the hyo-epiglottici may pull it a little forward in strong respirations, as in sighing, yawning, &c.

Voice and Speech. The *larynx* is the principal organ of the voice; for that being injured, the air passes through the windpipe without yielding any sound. By the larynx we understand an assemblage of cartilages, joined into a hollow machine, which receives the air from the fauces, and transmits it into the windpipe.

All the cartilages of the larynx are connected by various muscles and ligaments, with a certain degree of firmness, to the adjacent parts; and yet so that the whole is easily moveable together, as are also its several parts upon each other.

The whole larynx is suspended from the os hyoides by the ligaments proceeding towards the superior horns of the thyroide cartilage, and perfecting that cartilage from the middle of its basis to the conjunction of its plates. The same, together with the conjoined os hyoides, is capable of being raised considerably, at least half an inch above its mean altitude. This is performed by the biventer muscles, together with the geniohyoidei, genioglossi, styloglossi, stylohyoidei, stylopharyngei, thyreopalatini, hyothyroidei; all or some of which conspire together in that action. In this elevation the glottis is pressed together or made narrower, and the ligaments before mentioned approach nearer together. But thus, by the assistance of the action of the arytaenoides

noide muscles, together with the oblique and transverse ones, the glottis may be accurately closed, so as to resist with an incredible force the pressure of the whole atmosphere.

The same larynx may be, in like manner, depressed to about half an inch beneath its ordinary situation, by the sternohyoidei, sternothyroidei, and coracohyoidei, as they are called; and, when these are in action, also by the joint force of the anterior and posterior cricothyroidei. In this motion the arytænoide cartilages depart from each other, and render the glottis wider, which is also drawn open laterally by the muscles inserted into the sides of the arytænoide cartilages, together with the crico-arytænoidei postici and laterales, and thyreo-arytænoidei: these may also compress the ventricles of the larynx on which they are incumbent; the particular cartilages which make up the larynx can scarce be moved separately.

We shall now consider what action the air produces, when it is driven from the lungs in expiration through the windpipe into the larynx, and from them urged out through the glottis into the mouth, variously configured. The consequences or effects of this are, voice, speech, and singing. The voice, indeed, is only formed, when the air is expelled with so great a velocity through the contracted glottis, that it splits or makes a collision upon the ligaments of the glottis, so as to put the larynx into a tremor, which tremor is returned and continued or increased by the elasticity of these parts. Sound, therefore, arises from the conjunct trembling of the ligaments, together with the cartilages of the larynx at one and the same time, which we then call the voice, and is of a peculiar kind or modulation in every single class of animals, depending entirely upon the difference of the larynx and glottis. But when a trembling is not excited, the expired air causes a whisper.

The strength of the voice is proportionable to the
quantity

quantity of air blown out, together with the narrowness of the glottis; and, therefore, a large pair of lungs easily dilatable, with an ample cartilaginous and elastic larynx and windpipe, and the free echo of the nostrils, joined with a powerful expiration, all conduce to this effect. But acute and grave tones of the voice, we observe to arise from various causes. The former proceeds from a tension and narrowness of the glottis, and the latter from a relaxation and expansion of it. For thus, in the former, a greater number of aerial undulations are split in the same time upon the ligaments of the glottis, whence the tremors excited at the same time are more numerous; but when the glottis is dilated, the contrary of all this follows. And from the greater tension of the ligaments, the tremors in like manner become more numerous from the same stroke. Therefore, to produce an acute and shrill voice, the whole larynx is drawn upwards and forwards; and so much the more as the voice is required to be sharper, insomuch that the head itself is inclined backwards, by which the powers of the muscles elevating the larynx are rendered more full and effectual. The truth of this is confirmed by experience, by applying the fingers to the larynx when it forms an acute sound; for then, to raise the voice an octave, you will easily perceive it to ascend near half an inch. Also the same is evident from comparative anatomy, which demonstrate the narrowest glottis and the closest approximation of cartilages in singing birds, but an ample or broad glottis in hoarse animals and such as bellow or bleat. An instance of this we have in whistling, where the voice manifestly becomes more acute by a contraction or narrowness at the mouth: also in musical instruments, in which a narrowness of the mouth or opening that expels the air, with a celerity of the wind blown out, are the causes of an acute or shrill tone.

Gravity of the voice, on the contrary, follows from a depression of the larynx by the causes already described;

bed ; to which add a broad glottis and a very ample larynx. This is evident to the touch of the finger applied to the larynx when a person sings, by which the descent of it is manifestly perceived to be about an inch for every octave : hence the voice of males is more grave ; and hence the lowest degrees of the voice degenerate into a muteness or whispering.

Is the whole difference of tone owing to the length of the ligaments of the glottis, which is augmented when the scutiform cartilage is drawn forward, and the arytenoide ones backward ? Is it according to this rule, that the most acute tones are produced, which arise from the ligaments being exceedingly stretched, and thus vibrating with great celerity ? This has been confirmed by repeated experiments made by eminent men ; and some late anatomists have observed, that when the cords or ligaments of the glottis are tense, the peculiar voice of every kind of animal is produced by blowing air into its larynx : that this voice was more acute as the ligaments were more tense, and more grave as they were slackened ; that by shutting the whole ligament, the voice was suppressed ; by shutting the half, the voice was rendered an octave higher ; by shutting a third part, a fifth higher, &c. There are not wanting, however, doubts concerning this new theory, arising from the cartilaginous and bony structure of the glottis of birds, which of consequence must be immoveable, and not extensible ; from the voice most certainly becoming more acute, in whistling, from the mere contraction of the lips ; from the example of women, in which the larynx is softer, but the voice more acute, than in men ; from experiments which show, that more acute sounds are produced by bringing the ligaments of the glottis nearer into contact with each other ; from the perfect want of machines, by which the ligaments can be stretched, and which may bring the scutiform cartilage forward from the annular one. But seeing it appears from experiments, that a tension of the liga-

ments suffices for producing acute sounds, without the contraction of the glottis, we may believe that the different tension of the glottis contributes more to the diversity of voice than the different diameter of it.

Singing is when the voice, modulated through various degrees of acuteness and gravity, is expelled through the larynx, while it is trembling and suspended betwixt two contrary powers; and herein lies the principal difference betwixt the chanting of simple notes and the expression of words. Hence it appears to be a laborious action, by reason of the continual contractions of the muscles, which keep the larynx at an equilibrium: and hence it is, that singing makes a person hot; because in acute tones the narrower glottis much retards the expiration, while at the same time a great deal of air is required to give strength to the voice; to which, again, deep inspirations are necessary. Hence likewise the windpipe is rendered very dry, from the quicker passage or current of air: to prevent which, a great deal of mucus is required; and therefore it is that there are such numbers of mucous receptacles in the larynx; amongst which I am firmly of opinion the ventricles before described ought to be numbered.

Speech is performed by the larynx at rest, or held in the same place, in tones of voice differing but little in acuteness and gravity: but then the voice is variously changed or modulated by the organs of the mouth. Singing has a variation in the tone or cadence of the voice, together with a modulation of it by the organs of the mouth at the same time.

All speech is reducible to the pronunciation of letters, which differ in various nations; but most of them are alike all the world over. Of these, some are called *vowels*, which are made only by an expression of the voice through the mouth, without any application of the tongue to certain parts of the mouth. But consonants are formed by a collision of the tongue against certain parts of the mouth, lips, and teeth. But to be
more

more particular in these matters is beyond our purpose, which does not permit us to expatiate upon the beautiful art of pronunciation. That art, as an extraordinary instance of mechanical knowledge, has so accurately determined all the corporeal causes concurring to each letter, that, by inspection only, with the assistance of touch, letters pronounced are understood without hearing them; and the attentive person is thereby taught to imitate the same speech by a like use of the organs.

§. 5. *The Pharynx.*

THE pharynx is a muscular and glandular bag; the outer surface of which is closely joined to the inner surface of all that space which is at the bottom of the mouth, behind the posterior nares, uvula, and larynx, and which reaches from the cuneiform process of the os occipitis all the way to the œsophagus, which is the continuation of the pharynx. This space is bounded posteriorly by the muscles which cover the bodies of the first vertebræ of the neck, and laterally by the superior portions of both the internal jugular veins, and of both the internal carotid arteries, by the spinal apophyses of the os sphenoides, by the extremities of the apophyses petrosæ, by the os sphenoides, immediately above the internal alæ of the apophyses pterygoides, and by the neighbouring portion of both pterygoide muscles.

From these limits and adhesions of the pharynx we may pretty nearly determine its figure. It may be compared to the wide part of a covered funnel, of which the œsophagus is the narrow part or tube; or it may be called the *broad end of the œsophagus*, that and the pharynx taken together being compared to a trumpet. The pharynx may be divided into three parts; one superior, which is the arch of the pharynx; one middle, which is the body or great cavity; and one

inferior, which is the bottom, narrow portion, or sphincter. We are likewise to observe in it three openings; that of the arch, toward the nares; that of the body, toward the mouth; and that of the bottom, toward the œsophagus.

The arch is the broadest part of the pharynx; and ends on each side in an angle or point, toward the jugular fossulæ of the basis cranii. Afterwards the great cavity contracts a little toward the sides, all its other dimensions continuing the same; and behind the larynx it is again enlarged on each side, a very small space being left between it and the cricoid cartilage. The extremity of the lower portion is very narrow, and joins the basis of the cartilage just named.

The pharynx is made up partly of several distinct fleshy portions, which are looked upon as so many different muscles so disposed as to form a large cavity; and partly of a membrane which lines the inner surface of this whole cavity, and is a continuation of that of the nares and palate.

This membrane is wholly glandular; and it is thicker on the superior and middle portions of the pharynx than on the bottom or lower portion. Immediately above the first vertebra it forms several longitudinal rugæ very thick, deep, and short; and we generally find therein a collection of mucus in dead bodies. In the great cavity there are no rugæ, the membrane adhering, both there and in the upper part, very closely to the muscles. At the lower part where it is thinnest it covers likewise the posterior part of the larynx; and is very loose, and formed into irregular folds. It runs in a little on each side between the edges of the pharynx.

Muscles of the pharynx. Though almost all the muscular or fleshy portions of which the pharynx is composed, concur in the formation of one continued bag or receptacle, they are nevertheless very distinguishable from each other, not only by their different insertions,
from

from which they have been denominated, but also by the different directions of their fibres. They may be looked upon as three digastric muscles; the middle tendons of which lie backward in one longitudinal line, which in some subjects appears plainly like a *linea alba*.

The lowest of the muscular fibres make a complete circle backward between the two sides of the basis of the cartilago cricoides. This circle is the beginning of the œsophagus, and has been thought by some to form a distinct muscle called *œsophagus*. Besides the muscles which form the body of the pharynx, there are several other small ones connected with it; but of these sufficient descriptions have been already given in a former part of the work.

The particular uses of these muscles are very difficult to be determined. It is certain that those of the middle and lower portions of the pharynx serve chiefly for deglutition. Those of the upper portion, and some of those of the middle portion, may, among other functions, be useful in modifying the voice, according to the opinion of M. Santorini.

§ 6. *The Salival Glands, &c.*

By saliva we mean in general, that fluid by which the mouth and tongue are continually moistened in their natural state. This fluid is chiefly supplied by glands, called for that reason *glandulæ salivales*, of which they commonly reckon three pairs, two parotides, two maxillares, and two sublinguales. These are indeed the largest, and they furnish the greatest quantities of saliva; but there are a great number of other lesser glands of the same kind, which may be reckoned assistants or substitutes to the former. All these may be termed *salival glands*, and they may be enumerated in the following manner: Glandulæ parotides, glandulæ maxillares, glandulæ sublinguales, glandulæ molares, glandulæ buccales, glandulæ labiales, glandulæ

dulæ linguales, amygdalæ, glandulæ palatinæ, glandulæ uvulares, glandulæ arytenoidææ, glandula thyroidæa.

The parotides are two large, whitish glands, irregularly oblong and protuberant, situated on each side, between the external ear and the posterior or ascending ramus of the lower jaw, and lying on some part of the neighbouring masseter muscle. The superior portion of this gland lies before the cartilaginous meatus of the ear, and touches the apophysis zygomatica of the os temporis; and it is extended forward and backward under the lobe of the ear, as far as the mastoide apophysis.

From the anterior and superior portion of this gland, a white membranous duct or canal is produced by the union of a great number of small tubes representing so many roots. This duct runs obliquely forward on the outside of the masseter; and then perforates the buccinator from without inward, opposite to the interstice between the second and third dentes molares, where the hole or orifice represents the spout of an ewer.

This canal is named *ductus salivaris Stenonis*, or *ductus superior*. It is about the twelfth part of an inch in diameter, and on the outer side of the masseter muscle it receives sometimes one and sometimes two small ducts from a like number of little glands; which Haller calls *glandulæ accessoriæ*. The external carotid artery and vein, and the portio dura of the seventh pair of nerves, pass through the substance of the parotid gland, to which they give branches; and the facial artery and vein pass over its duct.

The maxillary glands are smaller and rounder than the parotides; and are situated each on the inside of the angle of the lower jaw, near the musculus pterygoidæus inferior. From the inside, or that which is turned to the musculus hyo-glossus, each of them sends out a duct in the same manner as the parotides; but it is smaller and longer, and goes by the name of *ductus salivaris Whartoni*, or *ductus inferior*.

This

This duct advances on the side of the musculus genio-glossus, along the inner part and superior edge of the glandula sublingualis, to the frænum of the tongue, where it terminates by a small orifice in form of a papilla.

The glandulæ sublinguales are likewise two in number, of the same kind with the former, only smaller, something oblong, and flatted like a blanced almond. They are situated under the anterior portion of the tongue, one on each side, near the lower jaw, on the lateral portions of the musculi mylo-hyoidæi which sustain them. The two extremities of each gland are turned backward and forward, and the edges obliquely inward and outward.

They are covered on the upper side by a very thin membrane, which is a continuation of the membrane that covers the under side of the tongue. They send out laterally several small short ducts which open near the gums by the same number of orifices, all ranked in the same line, at a small distance from the frænum, and a little more backward. In many animals we find particular ducts belonging to these glands, like those of the glandulæ maxillares, but they are not to be found so distinctly in men. The musculi genio-glossi lie between the two sublingual glands, and also between the two maxillary ducts. The arteries and veins of these and of the former glands belong to the lingual vessels, and the nerves are from the lingual branch of the fifth pair.

The molares are two glands nearly of the same kind with the former, each of them being situated between the masseter and buccinator; and in some subjects they may easily be mistaken for two small lumps of fat. They send out small ducts which perforate the buccinator, and open into the cavity of the mouth, almost over against the last dentes molares; and from thence M. Heister, who first described them, called them *glandulæ molares*.

All the inside of the cheeks, near the mouth, is full of small glandulous bodies, called *glandulæ buccales*, which open by small holes or orifices through the inner membrane of the mouth. The membrane which covers the inside of the lips, a continuation of that on the cheeks, is likewise perforated by a great number of small holes, which answer to the same number of small glands, called *glandulæ labiales*. The *glandulæ linguales* are those of the foramen cæcum of the basis of the tongue, which have been already described.

We have also explained the *glandulæ palatinæ*, or those that belong to the arch and septum of the palate; and the *glandulæ arytenoidææ* were described with the larynx. The uvular glands are only a continuation of the membrane of the palate in form of a small bunch of grapes. We might likewise reckon among the salival glands those of the superior portion of the pharynx mentioned in the description of that part, and also the follicles of the *membrana pituitaria* of the nares, and of the sinuses which communicate with these.

The *amygdalæ* are two glandular bodies of a reddish colour, lying in the interstices between the two lateral half-arches of the septum palati, one on the right, the other on the left side of the basis of the tongue. Their appearance is not unlike that of the outside of an almond-shell, both because their surface is uneven, and because it is full of holes big enough to admit the head of a large pin.

These holes, which represent a sieve, or a piece of net-work, are continued to an irregular sinus or cavity within the gland, filled commonly with a viscid fluid, which comes from the bottom of the sinus, and is from thence gradually discharged through these holes into the throat.

The thyroide gland is a large reddish mass which covers the anterior convex side of the larynx. It seems at first sight to be made up of two oblong glandular portions united by their inferior extremities, below the

cricoide cartilage, in such a manner as to have some resemblance to a crescent, with the cornua turned upward. It is of a moderate thickness, and bent laterally like the thyroide cartilage, from which its name is taken. The two lateral portions lie on the musculi thyrohyoidæi, and the middle or inferior portion on the crico-thyroidæi. The thyro-pharyngæi inferiores send fibres over this gland; and they communicate on each side, by some such fibres, with the sterno-thyroidæi and hyo-thyroidæi.

This gland seems to be of the same kind with the other salival glands, but it is more solid. Some anatomists thought they had discovered the excretory duct, but they mistook a blood-vessel for it. Sabatier observes, that the internal structure of this gland is flaccid and reddish, and formed of glandulous grains, less easily distinguished than in the other glands, and of vesicles of different sizes full of a yellowish oily liquor, which may serve the purpose of lubricating the parts in its neighbourhood. We sometimes meet with a kind of glandular rope which runs before the cartilago-thyroides, and disappears before the basis of the os hyoides.

This glandular rope goes out from the common basis of the lateral portions of the thyroide gland; and is lost between the musculi sterno-hyoidæi, behind the basis of the os hyoides, or between that basis and the epiglottis.

The glandulæ lymphaticæ will come in more properly in a latter part of this work, with the description of the absorbent system.

§ 7. *Of Mastication, Saliva, and Deglutition.*

SUCH hard and tough foods as consist of long parallel fibres, or are covered with a bony shell or cartilaginous skin, generally require mastication, to divide them into less cohering parts, that they may more easily yield their nourishment to the dissolving powers of the

the stomach. The more diligently they are subdivided in the mouth, the more relishing and agreeable they become to the stomach; and the nearer they approach to the nature of a fluid, the more easily are they digested or assimilated.

Therefore most animals are provided with teeth extremely hard; and as the materials of our food are various in their texture and firmness, nature has accordingly made our teeth variously figured. The office of the incisores is only, in the softer foods, to cut those which are tougher than the rest into smaller portions; such as the fibres and membranes of animals and vegetables, with the brittle seeds and kernels of fruits.

The canine teeth lacerate tough aliments, and hold fast such as require a long triture by the grinders.

Betwixt the molares the most compact or bony foods are interposed and broke, as the more tough and hard are ground smaller, while the lower teeth are urged obliquely and laterally against the moveable upper ones; and these are the teeth which perform principally what we are to expect from mastication of food. But that the teeth might break or grind the food with due strength and firmness, the uppermost are fixed into the sockets of the immoveable upper jaw, as the lower ones are into the lower moveable jaw, which is a single bone, and so joined with the temporals, that it may be drawn down from the upper jaws, and pulled up against them with a great force; and may be moved laterally to the right or left, forward and backward. Those various motions of the lower jaw depend upon the articulation of its oval heads, in which the lateral parts of the jaw terminate. This joint has the freer liberty in moving, and its incrustated cartilages have a longer duration, by the interposition of a small cartilaginous plate, betwixt the condyle of the jaw and tubercle of the temporal bone.

The muscles moving the lower jaw, which are weak in man, but very strong in brute animals, are the temporalis

poralis and masseter which act in concert ; but the temporal muscle brings the jaw more backwards, and the masseter forwards. The *pterygoideus internus* elevates or draws it to one side or the other alternately. The *pterygoideus externus* proceeds backward and downward into the outer part of the condyle of the lower jaw, which it moves laterally, and draws forward before the upper jaw.

The lower jaw is depressed, so as to open the mouth by the digastric or *biventer* muscle. Moreover, the mouth may be partly opened by all the other lower muscles of the jaw, os hyoides, and the larynx, as the genio-hyoideus, genio-glossus, sterno-hyoideus, sterno-thyroideus, coraco-hyoideus, and latissimus colli; although the latter rather draws the skin of the neck and face downward than the jaw itself. The genio-hyoideus and digastric muscles have a power of drawing the jaw backwards.

The lower jaw is elevated with a great force, so as to divide the food by the pressure of the upper and lower teeth against each other, by the action of the temporal masseter, and internal pterygoide muscles; the contraction of which appears by experiments to be very powerful, and sufficient to raise several hundred weight. The lateral and circular motions of the jaw upon one of its immoveable condyles are performed by the external and internal pterygoidei, acting either alone or together with the former. Thus the food is cut, lacerated, and ground to pieces; and if the mastication be continued diligently, it is, together with the liquors of the mouth, reduced into a kind of pulp.

During the trituration of the food in the mouth, there is continually poured into it a large quantity of a watery clear liquor, evaporable or insipid, or at least but very little saline, and containing but little earth; neither acid nor alkaline, although from thence may be obtained a very small portion of lixivial salt; of which there are numerous springs in the neighbourhood.

hood. A large quantity of this *saliva* is separated by numberless small glands of the lips and cheeks; and the juice poured out from the exhaling vessels of the tongue, mouth, and cheeks, is of the like kind, or rather more watery. As for the ductus incisivus, we are now sufficiently certain, that in the generality of persons it is blind, or discharges nothing into the mouth, and only gives passage to vessels and nerves running between the palate and nostrils.

The saliva is a watery liquor, with a moderate quantity of salt, partly lixivial, and partly culinary; with some oil and earth, dissolvable by the fire; with scarce any taste, unless given to it by disease or famine. The quantity produced is very considerable, as twelve ounces have been known to flow out from wounds in those parts in the space of an hour. By good-mannered people it is for the most part swallowed; and usefully, as it cannot be thrown away without hurting the digestion.

The salival glands especially, supply the watery humour called after their own name. Of these the principal are, the parotid, maxillary, and sublingual.

By the motion of the jaw in mastication, the salival glands are compressed, so as to discharge their juices into the mouth in great plenty. When the mouth is opened, the maxillary gland, being pressed by the digastric and mylo-hyoideus, throws forth abundance of saliva; the masseter when swelled presses the parotid gland, as does also the cutaneous muscle of the neck which lies over it: and it is this muscular pressure that excites the appetite, and pours the saliva into the mouth.

The food, therefore, being in this manner ground betwixt the teeth, and intermixed with the watery saliva and air, is broken down into a soft juicy pulp, pliable into any figure, and replete with elastic air, which, by the action of the latter, undergoes a farther dissolution, by the warmth of the parts exciting the
elasticity

elasticity of the air to expand and burst asunder the confining particles of the food, betwixt which it is included. In this act of mastication, the oily, aqueous, and saline parts of the food are intermixed the one with the other; the smell and taste of different ingredients are lost in one, which by the dilution of the saline parts with saliva renders the food flavourable: but such particles as are more volatile and penetrating, being directly absorbed by the bibulous vessels of the tongue and cheeks, enter straight into the blood-vessels and nerves, so as to cause an immediate recruit of the faculties.

But the motions which are necessary for turning round the food, applying it to the teeth, and conveying it through the different parts of the mouth in mastication, are administered by the tongue, cheeks, and lips. And first, the tongue being expanded so as to form a small concavity in its back or surface, takes up the food thus prepared, and conveys the charge by its moving powers to the parts for which it is designed. At one time the tongue, rendered narrow by lateral contraction, searches every part of the mouth with its tip, and turns out the latent food into a heap on its common concavity. At another time, applying its extremity to the fore-teeth, and raising itself up successively, it draws from the cavity of the mouth the fluids or chewed aliments, and conveys them to the fauces or back part of the mouth behind the teeth.

But these motions of the tongue are likewise governed by the muscles and membranes, largely inserted into the os hyoides; and this bone being drawn down by its respective muscles, depresses the tongue at the same time, and the lower jaw likewise, if the muscles of that be relaxed. These powers are the sterno-hyoides, sterno-thyroideus, hyo-thyroideus, thyreo-pharyngeus, and coraco-hyoides.

The other powers which elevate the os hyoides, together with the tongue, are its *styloglossus* muscle, sustained by a peculiar ligament of the upper jaw. The
style-

stylohyoideus, and second *stylohyoideus*, which, when it is present, resembles the former. All these muscles draw the tongue back, but laterally they elevate it. The *mylohyoideus* elevates the tongue, and fixes it in making various motions, or in like manner depresses the jaw. The *geniohyoideus*, being a companion of the *genioglossus*, pulls the tongue forward out of the mouth.

But the muscles of the cheeks variously move and press the food in the mouth. Others move it from the cavity of the cheeks into the inner cavity of the mouth behind the teeth, as we see in the *buccinator* when the mouth is shut. Others open the mouth for receiving the food; such as the double-headed proper elevator of the upper lip, and the elevator *anguli oris*; to which add, the *zygomaticus*, upper and lower; the *buccinator*, depressor *anguli oris*, and depressor *labii inferioris*. Others, again, close the lips, that the food received may not return out of the mouth; such as the *orbicularis* of each lip, the proper depressor of the upper lip, and the proper elevator of the lower lip, and that which serves in common for the elevation of both.

By these means the food, ground and mixed with the saliva into a soft pulp, collected from all parts of the mouth by the tongue into the arched space betwixt the teeth, is afterward, by the expansion and successive pressure of the tongue, conveyed backward behind the teeth; and, in this action, the tongue is expanded by the *hyoglossi* and *genioglossi*, and rendered a little concave by the *styloglossus*. And from thence it is next conveyed into the fauces.

For the tongue being raised by the *styloglossi*, and broadly applied to the palate, first by its apex, then also insensibly by its posterior extremity, presses the food successively towards the fauces, which at that time only afford an open passage. After this, the thick root and back part of the tongue itself, by the foremention-

ed muscles, and by the *stylohyoidei* and *biventer* carried backward, presses down the *epiglottis*, which stands up behind the tongue, connected therewith by numerous membranes, and perhaps by some muscular fibres. At the same time, the muscles elevating the pharynx all act together; such as the *biventer*, *geniohyoides*, *genioglossus*, *stylohyoideus*, *styloglossus*, *stylopharyngeus*, and the other elevators, which now draw the larynx upward and forward, that the *epiglottis*, being brought nearer to the convex root of the tongue, may be better closed or depressed. Hence it is necessary towards deglutition for the jaws to be closed, that by this means the *biventer* may have a firm support; and, together with the muscles already described, elevate the *os hyoides*. Thus the *epiglottis*, being inverted, shuts up and covers the passage very exactly, into the larynx, over which it is extended like a bridge for the aliment to pass over into the fauces.

The pharynx is dilated in its action by the powers serving to its elevation; such as the *stylopharyngeus*, the *thyreopalatinus*, &c. and it closely surrounds and follows the drink, on each side the *epiglottis*, above the larynx, that it may from thence fall into the *œsophagus*.

That the aliments might not regurgitate into the nostrils at the time when they are pressed into the dilated pharynx, a moveable velum or palate is interposed. The elevator of this velum, with its companion, forms an arch, which is moveable with the palate itself, between the two plates of the *thyreopalatinus* muscle, so as to be brought into a close contact with the sides of the nares and with the tubes, that none of the aliment may enter into either of them. But this elevator does not seem to have any considerable action in swallowing. At this time regurgitation into the nostrils is prevented by a constriction of the muscles of the pharynx, together with a depressure of the

the thyreopalatinus, which then manifestly draws the moveable velum downward and towards the tongue and pharynx. Add to these, the *circumflexus palati mollis*, which is able both to open the tube, and to press down the moveable velum of the palate. Thus the pharynx being contracted like a sphincter, drives down the food, without permitting any part to return back into the cavity of the nares. Hence, when the velum of the palate is vitiated, the aliments regurgitate into the nostrils, and a deafness ensues.

During this endeavour to depress the food by the pharynx, the velum, drawn back and expanded, is pulled down towards the tongue, by the action of the palatopharyngei, and by the circumflex muscles of the soft palate. These muscles, together with the glosso-palatinus, press the velum against the protuberant root of the tongue, and intercept any return to the mouth and nostrils. After there is no further danger of any part falling into the windpipe, the epiglottis is raised up again, as well by its own elasticity, as by the elevation of the tongue itself, by which it is drawn forward. Lastly, the depressed uvula is raised by the azygos, which arises from the tendons of the circumflexi muscles and levator of the soft palate.

A little after this follows an attempt to urge the food downward, which is exerted by the constrictor muscles of the pharynx which draw the fore parts towards the back, and the muscles which are partly transverse and partly ascend into the posterior surface of the pharynx. These muscles acting successively from above downward, according to their situation, drive the aliment into the œsophagus. At the same time the depressing muscles of the larynx, coracohyoideus, sternohyoideus, and sternothyreoideus, draw down the larynx forward, and lessening the capacity of the pharynx urge the food downward. But in this action, as the aliment passes by the posterior rima of the glottis, the arytaenoidei contract the larynx perpendicularly.

As various dry and rough bodies are frequently swallowed, it was necessary for the pharynx to be dilatable and not very sensible of pain; to which end the great quantity of mucus, which is collected in all parts of the fauces, greatly conduces. Therefore, in general, betwixt the nervous and innermost coat of the pharynx, are placed a great number of simple mucous follicles or cells, pouring out their mucus through short mouths; of a soft, viscid, and somewhat watery nature; but ropy, or drawing out into threads, not without oil, and abounding more with volatile salt and earth than the saliva itself.

The aliments are moved through the œsophagus as through an intestine. The longitudinal fibres, ascending to the cartilages of the larynx, dilate the gullet, opposite to the descending morsel. But when it is received, the longitudinal fibres equally dilate and elevate the gullet at that place which receives it. Then that part of the œsophagus where the morsel is seated, being irritated, contracts, and moves the food downwards. The muscle is strong, and very irritable.

This upper opening of the stomach is contracted or compressed in such a manner, by the lower muscle of the diaphragm, in every inspiration, as to confine the food within the stomach, and direct it in every expiration, by pressure, naturally towards the pylorus. By this means, the stomach is so closely shut, that in the most healthy man even wind or vapours are confined within the stomach; nor do they ever ascend but by a morbid affection.

C H A P. II.

Of the THORAX.

BY the thorax, we commonly understand all that part of the body which answers to the extent of the sternum, ribs, and vertebræ of the back, both outwardly and inwardly.

The thorax is divided into the anterior part, called commonly the *breast*; the posterior part, called the *back*; and the lateral parts, called the *right* and *left sides*.

The external parts of the thorax, besides the skin and membrana adiposa, are principally the mammæ; and the muscles which cover the ribs, and fill the spaces between them.

The muscles are the pectorales, majores, and minores, subclavii, serrati majores, serrati superiores posici, latissimi dorsi, and vertebrales; and to these we may add the muscles which cover the scapula.

The internal parts of the thorax are contained in the large cavity of that portion of the trunk which the ancients called the *middle venter*, but the moderns name it simply the *cavity of the breast*. This cavity is lined by a membrane named *pleura*, which forms the mediastinum; and contains the heart and lungs, with the vessels, &c. which go into or out from them: through it likewise the œsophagus passes to the stomach, and part of the nerves are contained in it which go to the contents of the abdomen.

External conformation of the thorax. The whole extent of the thorax in a living subject, is commonly determined not only by the sternum, vertebræ of the back and ribs, but also by all that space contained between the articulations of the two arms with the scapulæ and claviculæ; and in this sense, the outside of the thorax

is

is broader above than below in a healthy subject who has a moderate share of flesh on his bones.

The breadth of the upper part of the breast is owing to the *pectorales majores* and *latissimi dorsi* viewed directly forward or backward. But when we take a direct lateral view of the breast, it appears narrower above than below, not only in an entire subject, but even after every thing has been removed that covers the sides of the thorax, and in the skeleton itself.

The common integuments of the thorax are the same with those of the abdomen; and the convex side of this part of the body is likewise covered by several muscles. Anteriorly, we find the *pectorales majores* and *minores*, a large portion of the *serrati majores*, the *subclavii*, a portion of the *scaleni* and of the *obliqui abdominis externi*. Posteriorly, we have all the muscles which cover both sides of the scapula, the *serrati postici*, and a part of the *sacro-lumbares*, *longissimi dorsi*, *vertebrales*, &c. as in the history of the muscles. Among all the external parts of the thorax, only two are peculiar to it in the human body; namely, the two eminences called *mammæ*, which must therefore be described in this chapter.

Cavity of the thorax. The hard parts which form the sides of the cavity of the thorax, are, The twelve vertebræ of the back, all the ribs, and the sternum. The soft parts which complete the sides, are, The membrane called *pleura*, which lines the cavity; and the *musculi intercostales*, *sterno-costales*, and *diaphragma*, already described among the muscles.

All these hard and soft parts taken together, represent a kind of cage, in some measure of a conical figure, flatted on the foreside, depressed on the backside, and in a manner divided into two nooks by the figure of the vertebræ of the back, and terminated below by a broad arched basis inclined backward. The intercostal muscles fill up the interstices betwixt the ribs, and so complete the sides of the cavity: the basis

is the diaphragm ; and the pleura not only covers the whole inner surface of the cavity, but, by forming the mediastinum, divides it into two, one on the right, the other on the left.

§ 1. *Mammæ.*

THE name of *mammæ*, or *breasts*, is given to two eminences more or less round, situated in the anterior, and a little toward the lateral parts of the thorax, their centre or middle part lying almost opposite to the bony extremity of the sixth true rib on each side. Their size and figure vary in the different sexes and different ages.

In children of both sexes, and in males of all ages, they are commonly no more than cutaneous tubercles, or soft verrucæ of a reddish colour, called *papillæ* or *nipples* ; each of them being surrounded by a small, thin, and pretty broad circle or disk, more or less of a brownish colour and an uneven surface, termed *areola*.

In females come to the age of puberty, which is sometimes sooner, sometimes later, a third part is joined to the two former, which is a convex protuberance, more or less round, of about five or six fingers in breadth ; the papilla and areola being situated near the middle of its convex surface. This is what is properly termed *mamma* ; and it may be termed the *body of the breast*, when compared with the other two parts. It increases with age, and is very large in women with child, and in those that give suck. In old age it decreases and becomes flabby, losing its natural consistence and solidity.

Body of the Mamma. The body of the mamma is partly glandular, and partly made up of fat ; or it is a gland of the conglomerate kind, surrounded on all sides with cellular substance and fat. The glandular part is divided into little masses, separated also by fat, and which are divided into small granulæ, from which the

the lactiferous ducts arise: the cellulous pelliculæ support a great many blood-vessels, lymphatics, and serous or lactiferous ducts, together with the small glandular molculæ already mentioned; all of them being closely surrounded by two membranes continued from the pelliculæ.

The innermost of these two membranes, which is in a manner the basis of the body of the mamma, is thick and almost flat, adhering to the musculus pectoralis major. The second or external membrane is thinner, forming a particular integument for the body of the mamma, more or less convex, and adhering closely to the skin.

The corpus adiposum of the mamma in particular, is a spongy cluster, more or less interlarded with fat, or a collection of membranous pelliculæ, which, by the particular disposition of their outer sides, form a kind of membrane in shape of a bag, in which all the rest of the corpus adiposum is contained. The anterior or outer portion of this bag, or that which touches the skin, is very thin; but that side next the pectoralis major is thick.

Ductus lactiferi. The glandular body contains a white mass, which is merely a collection of membranous ducts, narrow at their origin, broad in the middle, and which contract again as they approach the papilla, near which they were supposed by some to form a circle of communication; but from the observations of the latest anatomists, the ducts have little or no communication with each other at this place. They are named *ductus lactiferi*; and, in their course, are accompanied by a ligamentous elastic substance, which terminates with them in the nipple: both this substance, and the ducts it contains, are capable of considerable extension and contraction; but in their natural state are moderately corrugated, so as to prevent an involuntary flow of milk, unless the distending force be very great from the accumulation of too great a quantity."

Areola. The coloured circle or disk already mentioned, is formed by the skin; the inner surface of which sustains a great number of small glandular molecularæ, of that kind which Morgagni calls *glandulæ sebaceæ*. They appear very plainly all over the areola, even on the outside, where they form little flat heights or eminences at different distances quite round the circle.

These tubercles are perforated by small holes, through which a kind of sebaceous matter, more or less liquid, is poured out to defend the areola and nipple. Sometimes one or more of the lactiferous ducts have been found to terminate upon the surface of the areola; from which it would appear Morgagni was led to think that the glands there are of the lactiferous kind.

Papilla. The tubercle which lies in the centre of the areola, is termed *papilla*, or the *nipple*. It is of different sizes in different ages and constitutions, and in the different conditions of females in particular. In women with child, or who give suck, it is pretty large, and generally longer or higher than it is thick or broad; and when it happens to be short, it causes great uneasiness to the child.

The texture of the nipple is spongy, elastic, and liable to divers changes of consistence, being sometimes harder, sometimes more flaccid. It seems to be made up chiefly of ligamentary fasciculi; the extremities of which form the basis and apex of the nipple. These fasciculi appear to be gently folded, or curled, during their whole length; and if, by drawing the fibres out, these folds be destroyed, they return again as soon as that action ceases.

Between these spongy and elastic fasciculi lie from twelve to fifteen or twenty particular tubes at small distances from each other, and all in the same direction. These tubes go to the basis of the papilla, and run through the apex in the same number of almost imperceptible holes or orifices; and as they are closely

ly united to the elastic fasciculi, they are folded in the same manner with them.

The body of the papilla is covered by a thin cutaneous production, and by the epidermis. Its outer surface is uneven, being full of small tubercles and wrinkles; among which those near the circumference of the nipple seem to have a transverse or annular disposition, which, however, is not uniform.

This disposition or direction seems to be owing to the elastic folds already mentioned: and from this simple structure it is easy to explain how infants in sucking the nipple, and women in drawing the teats of cows, bring out the milk. For the excretory tubes being wrinkled in the same manner as the fasciculi, do, by these wrinkles or folds; as by so many valves, hinder the milk contained in the ducts from flowing out; but when the nipple is drawn and elongated, the tubes lose their folds, and the passage becomes straight. Besides this, when they are drawn with a considerable force, the whole body of the mamma is increased in length and contracted in breadth, and thereby the milk is pressed into the open tubes; and thus by barely pressing the body of the breast, the milk may be forced toward the nipple, and even through the tubes: but those who understand the principles of the air-pump will more readily conceive the manner in which the child draws out the milk.

Arteries, veins, nerves, &c. The arteries and veins distributed through the mammæ, are ramifications of the arteriæ and venæ mammariae; of which one kind comes from the subclaviæ, and are named *mammariæ internæ*; the others from the axillares, called *mammariæ externæ*.

These vessels communicate with each other, with those near them, and with the vasa epigastrica. The nerves come chiefly from the costales, and, by means of these, communicate with the great nervi sympathetici. The mamma has numerous lymphatic vessels,

which Wrisberg observes run in two sets; and that most of these vessels gradually collect into a great plexus, which go to the axillary glands; but others enter the thorax through the interstices of the ribs, near the sternum, and communicate with the glands behind the mammary vessels.

Uses. The use of the mammæ in the nourishment of children is known to all the world; but it is not certainly known what the papillæ and areolæ in males can be designed for. Milk has been observed in them in children of both sexes; and this happened to one of Winslow's brothers when he was about two years of age. See Art. Conception.

§ 3. *Pleura and Mediastinum.*

THE pleura is a membrane which adheres very closely to the inner surface of the ribs, sternum, and musculi intercostales, sub-costales, and sterno-coastales, and to the convex side of the diaphragm. It is of a very firm texture, and is supplied with blood-vessels and nerves, in all which it resembles the peritonæum; and likewise in that it is made up of an inner true membranous lamina, and a cellular substance on the outside.

Each side of the thorax has its particular pleura, entirely distinct from the other, and making, as it were, two great bladders, situated laterally with respect to each other in the great cavity of the breast, in such a manner as to form a double septum or partition running between the vertebræ and the sternum, their other sides adhering to the ribs and diaphragm.

This particular duplicature of the two pleuræ is termed *mediastinum*. The two laminæ of which it is made up are closely united together near the sternum and vertebræ; but in the middle, and toward the lower part of the fore-side, they are separated by the pericardium and heart, as we shall see hereafter. A little more backward they are parted in a tubular form by the

the œsophagus, to which they serve as a covering; and in the most posterior part, a triangular space is left between the vertebræ and the two pleuræ from above downward, which is filled chiefly by the aorta.

Before the heart, from the pericardium to the sternum, the two laminæ adhere very closely; and there the mediastinum is transparent, except for a small space near the upper part, where the thymus is situated: so that in this place there is naturally no interstice or particular cavity. The apparent separation is owing entirely to the common method of raising the sternum, as was plainly demonstrated by Bartholinus, in his *Treatise of the Diaphragm*, published at Paris in 1676.

The mediastinum does not commonly terminate along the middle of the inside of the sternum, as the common opinion has been. Winslow demonstrated in the year 1715, to the Royal Academy of Sciences, that from above downward it inclines toward the left side; and that if, before the thorax is opened, a sharp instrument be run through the middle of the sternum, there will be almost the breadth of a finger between the instrument and the mediastinum, provided that the sternum remain in its natural situation, and the cartilages of the ribs be cut at the distance of an inch from it on each side.

From all this we see, not only that the thorax is divided into two cavities entirely separated from each other by a middle septum without any communication; but also that, by the obliquity of this partition, the right cavity is greater than the left; but there are exceptions to the above descriptions. Lieutaud says he has met with several subjects in which the mediastinum descended along the middle of the sternum; and others, where it was inclined to the left side. Sabatier observes this is rare; but he has likewise met with several examples, where an instrument thrust through the middle of the sternum got into the left cavity of the thorax: and he has sometimes seen the right lamina of
the

the mediastinum fixed to the middle of the sternum, while the left one was fixed opposite to the articulation with the cartilages of the ribs; a space being left between the two, which was filled with cellular substance, intermixed with fat. From hence we may judge of the uncertainty of trepanning the sternum, which the ancients have recommended in some cases of abscesses, &c. between the layers of the mediastinum.

The pleura is connected to the membranous portion of the sternum, ribs, and muscles; to the diaphragm, pericardium, thymus, and vessels; and, in a word, to whatever lies near its convex side.

The surface of the pleura turned to the cavities of the breast, is continually moistened by a lymphatic serosity which transudes through the pores of the membranous portion. This fluid is said to be secreted by imperceptible glands; but the existence of these glands has not been hitherto demonstrated.

Arteries and veins. The arteries and veins of the pleura are chiefly ramifications of the intercostals; and these ramifications are exceedingly numerous, and for the most part very small. The *mammariæ internæ* and *diaphragmaticæ* likewise send branches hither, which communicate very frequently with those that come from the intercostals.

The mediastinum has particular vessels, called *arteriæ* and *venæ mediastinæ*, which are commonly branches of the *subclaviæ*. The *mammariæ internæ* send likewise ramifications to the fore-part of it, the *diaphragmaticæ* to the lower part, and the *intercostales* and *œsophageæ* to the back-part.

Nerves. The nerves, which are few, are ramifications of the true intercostales. Near the *vertebræ* they communicate with the great sympathetic nerves, and but very little with the eighth pair.

Use. The pleura serves in general for an inner integument to the cavity of the thorax. The mediastinum cuts off all communication between the two cavities,

ties, and hinders one lung from pressing on the other when we lie on one side. It likewise forms receptacles for the heart, pericardium, œsophagus, &c.; and it is continued over the lungs in the manner which shall be explained hereafter.

Before we leave the pleura, it must be observed that it adheres firmly to the ribs. This adhesion keeps the pleura stretched, and hinders it from slipping or giving way. It likewise renders this membrane extremely sensible of the least separation caused by a coagulated lymph or accumulated blood; the nervous filaments being likewise in this case very much compressed in inspiration by the swelling of the intercostal muscles.

§ 4. *Thymus.*

THE thymus is an oblong very soft glandular body, round on the upper part, and divided below into two or three great lobes; of which that toward the left hand is the longest. In the fœtus it is of a pretty large size; less in children, and very little in aged persons. In children it is of a white colour, sometimes mixed with red; but in an advanced age its colour is generally dark.

The greatest part of the thymus lies between the duplicature of the superior and anterior portion of the mediastinum, and the great vessels of the heart; from whence it reaches a little higher than the tops of the two pleuræ, so that some part of it is out of the cavity of the thorax; and in the fœtus and in children, it lies as much without the thorax as within it, and is then composed of numerous lobules, each inclosed in a thin covering, and united together by cellular substance: these are hollow within, and communicate together somewhat like the cells of the lungs, but they contain a milky fluid, which readily appears after an opening is made, but this fluid vanishes soon after birth. Among the various opinions about the use of this substance, some

some have thought it served only to fill a part of the thorax of the fœtus in the collapsed state of the lungs, because its size decreases after the lungs are dilated.

Its particular inward structure and secretions are not as yet sufficiently known to determine its uses ; which, however, seem to be designed more for the fœtus than for adults. It has vessels belonging to it, called *arteriæ* and *venæ thymicæ* ; which are branches from the *laryngæ inferior* and *mammaria interna*.

§ 5. *Pericardium*.

THE heart, with all the parts belonging to it, is contained in a membranous capsula, called *pericardium* ; which is in some measure of a conical figure, and somewhat bigger than the heart ; but the difference must be less during life when the heart is full of blood. It is not fixed to the basis of the heart, but round the large veins above the auricles before they send off the ramifications, and round the large arteries before their divisions.

The pericardium is made up of three laminæ ; the middle and chief of which is composed of very fine tendinous filaments, which are best seen in old persons ; they are closely interwoven, and cross each other in different directions. The internal lamina seems to be a continuation of the outer coat of the heart, auricles, and great vessels. The trunks of the aorta and pulmonary artery have one common coat, which contains them both as in a sheath, and is lined on the inside by a cellular substance, chiefly in that space which lies between where the trunks are turned to each other, and the sides of the sheath. There is but a very small portion of the inferior vena cava contained in the pericardium.

It is the middle lamina which chiefly forms the pericardium ; and the figure of this bag is not simply conical, its apex or point being very round, and the ba-
sis

sis having a particular elongation which surrounds the great vessels, as has been already said, as amply as the other portion surrounds the heart.

The pericardium is closely connected to the diaphragm, not the apex, but exactly at that place which answers to the flat or lower side of the heart; and it is a very difficult matter to separate it from the diaphragm in dissection, the tendinous fibres of the one substance intermixing with those of the other. This adhering portion is in some measure of a triangular shape, answering to that of the lower side of the heart; and the rest of the bag lies upon the diaphragm, without any adhesion.

The external lamina, or common covering, as it may be called more properly, is formed by the duplicature of the mediastinum. It adheres to the proper bag of the pericardium by the intervention of the cellular substance in that duplicature, but leaves it where the pericardium adheres to the diaphragm, on the upper surface of which it is spread, as being a continuation of the pleura.

The internal lamina is perforated by an infinite number of very small holes, through which a serous fluid continually transudes, in the same manner as in the peritonæum, there being no glands for this purpose, as some have supposed. The pericardium, at its forepart, receives arteries from the *mammaria interna* and *diaphragmatica*: the lower part is supplied by the *diaphragmatica*; while the posterior surface has branches from the *subclavia*, from the *mammaria*, and from the *aorta*, &c. The veins correspond with the arteries, excepting some which go to the *vena azygos*. The nerves are chiefly from the eighth pair and great sympathetic. This fluid being gradually collected after death, makes what is called *aqua pericardii*, which is found in considerable quantities in opening dead bodies while they remain fresh. Sometimes it is of a reddish colour,

lour, which may be owing to a transfusion of blood through the fine membrane of the auricles.

§ 6. *Of the Heart.*

Situation in general and conformation. THE heart is a muscular body situated in the cavity of the thorax, on the anterior part of the diaphragm, between the two laminæ of the mediastinum. It is in some measure of a conical figure, flattened on the sides, round at the top, and oval at the basis. Accordingly we consider in the heart, the basis; apex; two edges, the one right and the other left; and two sides, one of which is generally flat and inferior, the other more convex and superior.

Besides the muscular body, which chiefly forms what we call the *heart*, its basis is accompanied by two appendices, called *auriculæ*, and by large blood-vessels; of which hereafter: and all these are included in the pericardium.

The heart is hollow within, and divided by a septum which runs between the edges into two cavities, called *ventriculi*; one of which is thick and solid, the other thin and soft. This latter is generally termed the *right ventricle*, the other the *left ventricle*; though, in their natural situation, the right ventricle is placed more anteriorly than the left, as we shall see hereafter.

Each ventricle opens at the basis by two orifices; one of which answers to the auricles, the other to the mouth of a large artery; and accordingly one of them may be termed the *auricular orifice*, the other the *arterial orifice*. The right ventricle opens into the right auricle, and into the trunk of the pulmonary artery; the left into the left auricle, and into the great trunk of the aorta. At the edges of these orifices are found several moveable pelliculæ, called *valves* by anatomists; of which some are turned inward toward the cavity of the ventricles, called *triglochines*, or *tricuspides*; others are turned toward the great vessels, called *semilunares*,

or *sigmoidales*. The valvulæ tricuspidæ of the left ventricle are likewise termed *mitrales*.

Ventriculi. The inner surface of the ventricles is very uneven, many eminences and cavities being observable therein. The most considerable eminences are thick fleshy productions, called *columnæ*. To the extremities of these pillars are fastened several tendinous cords, the other ends of which are joined to the valvulæ tricuspidæ. There are likewise other small short tendinous ropes along both edges of the septum between the ventricles. These small cords lie in an obliquely transverse situation, and form a kind of net-work at different distances.

The cavities of the inner surface of the ventricles are small deep fossulæ or lacunæ placed very near each other, with small prominent interstices between them. The greatest part of these lacunæ are orifices of the venal ducts, to be described hereafter.

Structure of the ventricles. The fleshy or muscular fibres of which the heart is made up, are disposed in a very singular manner, especially those of the right or anterior ventricle; being either bent into arches or folded into angles.

The fibres which are folded into angles are longer than those which are only bent into arches. The middle of these arches, and the angles of the folds, are turned toward the apex of the heart, and the extremities of the fibres toward the basis. These fibres differ not only in length, but in their directions, which are very oblique in all, but much more so in the long or folded fibres than in the short ones, which are simply bent.

It is commonly said that this obliquity represents the figure 8; but the comparison is very false, and can only agree to some bad figures drawn by persons ignorant of the laws of perspective.

All these fibres, regard being had to their different obliquity and length, are disposed in such a manner,

as

as that the longest form partly the most external strata on the convex side of the heart, and partly the most internal on the concave side; the middle of the arches and the angles meeting obliquely and successively to form the apex.

The fibres situated within these long ones grow gradually shorter and straighter all the way to the basis of the heart, where they are very short and very little incurvated. By this disposition, the sides of the ventricles are very thin near the apex of the heart, and very thick toward the basis.

Each ventricle is composed of its proper distinct fibres; but the left ventricle has many more than the right, its substance being considerably thicker. Where the two ventricles are joined, they form an impervious septum which belongs equally to both. Opposite to this septum a groove is seen on the outside of the heart; one running longitudinally on its upper, the other on its under surface: in these grooves the great branches of the coronary arteries and veins are lodged.

There is this likewise peculiar to the left ventricle, that the fibres which form the innermost stratum of its concave side, form the outermost stratum of the whole convex side of the heart, which consequently is common to both ventricles; so that, by carefully unravelling all the fibres of the heart, we find it to be made up of two bags contained in a third.

The anterior or right ventricle is somewhat larger than the posterior or left, as was well observed by the ancients, and clearly demonstrated by M. Helvetius. The left is a little longer than the right, and in some subjects they end exteriorly in a kind of double apex. But it appears from experiments, that the inequality between the parts of the right and those of the left side of the heart, are not so great during life as after death; for, in the hearts of animals killed by cutting across the vessels of the neck, and in those of persons who have died in battle from a wound in

the vena cava or pulmonary artery, the inequality is less than we commonly perceive. This was first observed by M. Vieussens Professor of Anatomy at Altorf.

Sabatier has made numerous experiments on animals; the result of which is nearly the same with that mentioned above.

All the fibres are not directed the same way, though they are all more or less oblique: for some end toward the right hand, others toward the left, some forward, some backward, and others in the intermediate places; so that, in unravelling them, we find that they cross each other gradually, sometimes according to the length of the heart, and sometimes according to its breadth.

The tubes which cross each other transversely are much more numerous than those which cross longitudinally; which ought to be taken notice of, that we may rectify the false notions that have been entertained concerning the motion of the heart; namely, that it is performed by a contortion or twisting like that of a screw, or that the heart is shortened in the time of contraction, and lengthened in dilatation.

The fibres which compose the inner or concave surface of the ventricles do not all reach to the basis; some of them running into the cavity, and there forming the fleshy columnæ, to which the loose floating portion of the tricuspidal valves is fastened by tendinous ropes.

Besides these fleshy pillars, the internal fibres form a great many eminences and depressions, which not only render the inner surface of the ventricles uneven, but give it a great extent within a small compass. Some of these depressions are the orifices of the venal ducts found in the substance of the ventricles, which have been already mentioned. The circumferences of the great openings at the basis of the heart are tendinous, and may be looked upon as the common tendon of all the fleshy fibres of which the ventricles are composed.

Valvula. The valves at the orifices of the ventricles
 VOL. II. P are

are of two kinds : one kind allows the blood to enter the heart, and hinders it from going out the same way ; the other kind allows the blood to go out of the heart, but hinders it from returning. The valves of the first kind terminate the auriculæ ; and those of the second lie in the openings of the great arteries. The first are termed *semilunar* or *sigmoidal valves* ; the others, *triglobines*, *tricuspidal*, or *mitral*.

The tricuspidal valve of the right ventricle is of a circular form, and is fixed to the opening of the auricle, while the other end is attached to the internal surface of the ventricle. The circular membrane of the valve soon divides into many parts, three of which are more considerable than the rest ; and these have got the name of *tricuspid valves*, though they are now generally considered as forming one. That which is next the mouth of the pulmonary artery is the largest, and is said by some to prevent the blood from getting into the artery while the ventricle is filling. It has three triangular productions, very smooth and polished on that side which is turned towards the auricle ; and on the side next the cavity of the ventricle, they have several membranous and tendinous expansions, and their edges are notched or indented. The valve of the auricular orifice of the left ventricle is of the same shape and structure, but it is only divided into two parts ; and, from some small resemblance to a mitre, has been named *mitralis*. That which is next the mouth of the aorta is the largest.

The semilunar valves are six in number, three belonging to each ventricle, situated at the mouths of the great arteries ; and they may be properly enough named *valvulæ arteriales*. Their concave sides are turned toward the cavity of the arteries, and their convex sides approach each other. In examining them with a microscope, we find fleshy fibres lying in the duplicature of the membranes of which they are composed.

They

They are truly semilunar, or in form of a crescent, on that side by which they adhere: but their loose edges are of a different figure, each of them representing two small crescents; the two extremities of which meet at the middle of this edge, and there form a kind of small papilla, first described by Arantius, and afterwards by Morgagni, and therefore named from them.

The aorta in general. The great artery that goes out from the left ventricle, is termed *aorta*. As it goes out, it turns a little toward the right hand, and then bends obliquely backward, to form what is called *aorta descendens*; which we shall have occasion to mention again hereafter. At the beginning of the aorta, and behind the semilunar valves, three elevations are observed on the outside: these correspond to an equal number of pits on the inside, which, from the discoverer, have been called *sinuses of Valsalva*. Their use is not well known. From about the middle of the convex side of this curvature three great branches arise, which furnish an infinite number of ramifications to the head and upper extremities of the body; as the descending aorta does in the same manner to the thorax, abdomen, and lower extremities.

The arteria pulmonaris in general. The trunk of the artery which goes out from the right ventricle, is called *arteria pulmonaris*. This trunk, as it is naturally situated in the thorax, runs first of all directly upward for a small space; then divides laterally into two principal branches, one for each lung; that which goes to the right lung being the longest, for a reason that shall be given hereafter.

Auriculæ. The auricles are muscular bags situated at the basis of the heart, and their capacities are in proportion to those of their respective ventricles; one towards the right ventricle, the other towards the left, and joined together by an inner septum and external communicating fibres, much in the same manner with

the ventricles; one of them being named the *right auricle*, the other the *left*. They are very uneven on the inside, but smother on the outside; and terminate in a narrow, flat, indented edge, representing a cock's comb, or in some measure the ear of a dog; this properly gets the name of *auricle*, the larger and smooth part of the cavity being called *sinus venosus*, but as the two parts make one general cavity, the name of *auricle* is commonly applied to the whole. They open into these orifices of each ventricle, which I name *auricular orifices*; and they are tendinous at their opening, in the same manner as the ventricles.

The right auricle is larger than the left; and it joins the right ventricle by a common tendinous opening, as has been already observed. It has two other openings united into one, and formed by two large veins which meet and terminate there, almost in a direct line, called *vena cava superior* and *inferior*. Highmore has described an eminence in form of a valve, placed between the mouths of the two *venæ cavæ*: this he supposed directs the blood from the veins into the auricle; afterwards Lower described and delineated it; and other anatomists have called it *tuberculum Loweri*, till Morgagni denied its existence in the human subject. At the mouth of the inferior cava we find a membrane in form of a crescent, described by Eustachius, and named from him. Its convex edge is fixed to the union of the vein and the right auricle, while its concave edge is turned upwards over the mouth of the vein. It is most complete in the foetus; but it is found likewise in a person of advanced age, though it sometimes, from use, has a reticular appearance. It is said to prevent the blood in the auricle from returning into the cava; but it has a different use in the foetus. The notched edge of this auricle terminates obliquely in a kind of obtuse point, which is a small particular production of the great bag, and is turned toward the middle of the basis of the heart.

The

The whole inner surface of the right auricle is uneven, by reason of a great number of prominent lines which run across the sides of it, and communicate with each other by smaller lines, which lie obliquely in the interstices between the former. The lines of the first kind represent trunks, and the other small branches in an opposite direction to each other. In the interstices between these lines, the sides of the auricle are very thin and almost transparent, seeming to be formed merely by the external and internal coats of the auricle joined together, especially near the point.

The left auricle is in the human body a kind of muscular bag or reservoir, of a pretty considerable thickness and unequally square, into which the four veins open called *venæ pulmonares*, and which has a distinct appendix belonging to it, like a third small auricle. This bag is very even on both surfaces, and is therefore called *sinus venosus*; but to distinguish it from the one on the right side, it is called *sinus venosus sinister*. However, the bag and appendix have but one common cavity; and therefore may still be both comprehended under the common name of the *left auricle*. In men, the small portion may likewise be named *the appendix of the left auricle*; but in other animals, the case is different.

This small portion or appendix of the left auricle is of a different structure from that of the bag or large portion. Exteriorly, it resembles a small oblong bag, bent different ways, and indented quite round the edges. Interiorly, it is like the inside of the right auricle. The whole common cavity of the left auricle is smaller in an adult subject than that of the right; and the fleshy fibres of this left auricle cross each other obliquely, in strata differently disposed.

Arteriæ & venæ coronariæ. Besides the great common vessels, the heart has vessels peculiar to itself, called *the coronary arteries and veins*; because they in some

measure crown the basis of the heart. The coronary arteries, which are two in number, go out from the beginning of the aorta, and afterwards spread themselves round the basis of the heart, to the substance of which they send numerous ramifications.

Vieussens believed that some of the branches of the coronary artery opened into the cavities of the ventricles and auricles; for, by throwing a fine injection into these arteries, he found it run out on all sides of the right ventricle and auricle. Thebesius of Allemand, being nearly of the same opinion, endeavoured to prove, that there were veins which carried part of the blood from the coronary arteries immediately into the cavities of the heart; and these have therefore got the name of *veins of Thebesius*, though he is not the first discoverer. Winslow, Haller, and several others, describe such veins; but Duverney, after injecting the heart of an elephant, doubts of their existence. Senac, who has paid much attention to this subject, denies it altogether; and Sabatier coincides with him in opinion.

The nerves of the heart are from the par vagum and great sympathetics; these form the cardiac plexus, which sends off branches to the pericardium, to the roots of the great vessels, and are spent at last on the different parts of the heart.

There are seldom more than two arteries; of which one lies toward the right hand, the other toward the left of the anterior third part of the circumference of the aorta. The right coronary artery runs in between the basis and right auricle, all the way to the flat side of the heart, and so goes half way round. The left artery has a like course between the basis and left auricle; and before it turns on the basis, it sends off a capital branch, which runs in between the two ventricles. Another principal branch goes off from the union of the two arteries on the flat side of the heart; which running to the apex, there joins the other branch,

The

The coronary veins are distributed exteriorly, much in the same manner. The largest opens into the posterior inferior part of the right auricle, by an orifice which is furnished with a valve, first described by Eustachius. Besides the coronary veins, the heart has other anterior veins, which have been called by Vieussens *venæ innominatæ*. Some of them go into the right auricle, others end in the right ventricle; and there are other veins still smaller, which are found in the substance of the heart, and which terminate in the right sinus and auricle.

Particular situation of the heart. The heart lies almost transversely on the diaphragm, the greatest part of it being in the left cavity of the thorax, and the apex being turned toward the bony extremity of the sixth true rib. The basis is toward the right cavity; and both auricles, especially the right, rest on the diaphragm; but the situation of the heart during life changes a little, according to the state of respiration, and to the position of the body.

The origin or basis of the pulmonary artery is, in this natural situation, the highest part of the heart on the foreside; and the trunk of this artery lies in a perpendicular plane, which may be conceived to pass between the sternum and spina dorsi. Therefore some part of the basis of the heart is in the right cavity of the thorax; and the rest, all the way to the apex, is in the left cavity; and it is for this reason that the mediastinum is turned toward that side.

According to this true and natural situation of the heart, the parts commonly said to be on the right side are rather anterior, and those on the left side posterior; and that side of the heart which is thought to be the foreside is naturally the upper side, and the backside consequently the lower side.

The lower side is very flat, lying wholly on the diaphragm; but the upper side is a little convex through its whole length, in the direction of the septum be-

tween the ventricles. And it may be proper here to remark, that though commonly received terms of art may still be retained, yet it is necessary to prevent their communicating false ideas to those who have not had an opportunity of making observations themselves, or of being instructed by others.

Uses in general. The heart and parts belonging to it are the principal instruments of the circulation of the blood. The two ventricles ought to be considered as two syringes so closely joined together as to make but one body, and furnished with suckers placed in contrary directions to each other, so that by drawing one of them, a fluid is let in, and forced out again by the other.

The heart is made up of a substance capable of contraction and dilatation. When the fleshy fibres of the ventricles are contracted, the two cavities are lessened in an equal and direct manner, not by any contortion or twisting, as the false resemblance of the fibres to a figure of 8 has made anatomists imagine. For if we consider attentively in how many different directions and in how many places these fibres cross each other, as has been already observed, we must see clearly, that the whole structure tends to make an even, direct, and uniform contraction, more according to the breadth or thickness than according to the length of the heart; because the number of fibres situated transversely, or almost transversely, is much greater than the number of longitudinal fibres.

The fleshy fibres thus contracted do the office of suckers, by pressing upon the blood contained in the ventricles; which blood being thus forced toward the basis of the heart, presses the tricuspidal valves against each other, opens the semilunares, and rushes with impetuosity through the arteries and their ramifications, as through so many elastic tubes.

Systole. The blood thus pushed on by the contraction of the ventricles, and afterwards pressed by the elastic

stic arteries, enters the capillary vessels, and is from thence forced to return by the veins to the auricles, which, like retirements, porches, or antichambers, receive and lodge the blood returned by the veins during the time of a new contraction. This contraction of the heart is by anatomists termed *systole*.

Diaстole. The contraction or *systole* of the ventricles, ceases immediately, by the relaxation of their fleshy fibres; and in that time the auricles which contain the venal blood, being contracted, force the blood through the tricuspidal valves into the ventricles, the sides of which are thereby dilated, and their cavities enlarged. This dilatation is termed *diaстole*.

Circulation. In this manner does the heart, by the alternate *systole* and *diaстole* of its ventricles and auricles, push the blood through the arteries to all the parts of the body, and receive it again by the veins. This is called the *circulation of the blood*, which is carried on in three different manners.

The first and most universal kind of circulation is that by which almost all the arteries of the body are filled by the *systole* of the heart, and the greatest part of the veins evacuated by the *diaстole*.

The second kind of circulation opposite to the first, is through the coronary vessels of the heart, the arteries of which are filled with blood during the *diaстole* of the ventricles, and the veins emptied during the *systole*.

The third kind of circulation is that of the left ventricle of the heart; through the venal ducts of which a small quantity of blood passes, without going through the lungs, which is the course of all the remaining mass of blood.

Besides these three different kinds of circulation, there are some peculiarities in the course of the blood, which may be looked upon as particular circulations. Such is the passage of the blood through the liver, corpora

pora cavernosa of the parts of generation, and through the cavernous sinuses of the dura mater.

NATURE hath given a heart to most animals, even to many insects and worms: to others she hath denied it; and these are the most simple of all animals, even very large ones, though they are irritable throughout their whole body; as, for instance, the prickly hydra. Those animals which have no hearts, have also no vessels.

The veins which carry back the blood from the whole body to the heart, if we except those of the lungs, are reducible to two, which are the *venæ cavæ*.

The blood of the two *venæ cavæ* is propelled by a muscular force, in either vein, into the right auricle. These veins, as far as they lie within the breast, are endowed with strong and irritable muscular fibres, by whose contraction the blood is driven into the neighbouring auricle.

In like manner, the auricle, being irritated, is contracted on all sides. And, first, by a constriction of its muscular fibres, the anterior semicylinder of the auricle is reduced to a plane; while the same fibres, by their contraction, bring back the middle arch towards the anterior extremity or beginning of the heart, and likewise towards its posterior extremity or sinus. Then the appendix to the auricle descends, and is contracted transversely by itself, while the lower part ascends; and thus the auricle becomes shorter. Again, the left edge turns evidently to the right, and the right edge a little to the left; and thus the auricle is rendered narrower. Thus the blood of both *cavæ*, being mixed together in the beginning of the heart now disencumbered, is driven through the edges of the open valve, in such a manner as to urge the valves of the right ventricle close to the sides of the heart. But the blood is now hindered from returning again into the lower cava, both by the contraction of the auricle, the resistance of the succeeding blood from the

the abdomen, and of the *Eustachian valve*; and upwards it is hindered from ascending, both by the motion and weight of the consequent blood. It is driven back, however, on both sides, if there happens to be any obstacle in the lungs.

The usefulness of the *valvulæ tricuspidæ* is evident enough; for the right auricle being contracted, the blood contained in the right porch of the heart, at the loose extremity of the auricle, being impelled from the circumference towards the axis, like a wedge, separates the pendulous portions of the valves, and presses them to the sides of the heart. Thus is filled the right ventricle of the heart, while the uppermost valve shuts the pulmonary artery, lest the blood, by the weak impulse of the auricle, should flow into that artery: the blood thus received, and confined within the right ventricle of the heart, is, by the strong contraction thereof, more powerfully expelled into the artery.

The sensible flesh of the heart, being irritated by the quantity and weight of this warm blood, is thereby solicited to a contraction: for that the heart, being irritated, will contract itself in a person dying, or even lately dead, is proved by injections of water, and inflations of air, whereby the heart, then quiescent, is recalled to its motion.

The heart's motion is performed by *muscular fibres*; the originations of which, in general, are from rings formed of the cellular substance, compacted into a callous ligament, agreeable to the description already given, and with which all the larger blood-vessels at their opening into the heart are surrounded. From thence the fibres, which arise, descend gradually in an oblique winding course towards the left side, and forward to the apex, in many distinct plates, and sometimes a little traversing each other, the middle ones being the most transverse, while the outermost and innermost descend in a straighter line. In the flat side of the heart there are few fibres; and so thin, that when you have removed

ved the fat, the cavity appears almost uncovered. That which is called the left ventricle, is, however, very firmly invested by the fibres; which, after surrounding the same ventricle, form a slight decussation in the septum cordis with the fibres of the right ventricle, and are interwoven with them. Some of these fibres descend into the cavities of the ventricles, and form there the fleshy columns. Others at the tip of the heart, are wound in a vortical or whirling position, the two horns ending by a strong fasciculus or bunch in each ventricle. A very thin and smooth membrane covers the external and internal surface of these fibres; but the external membrane, especially where it is spread over the coronary vessels, contains much fat beneath it. It is difficult to distinguish any thing more particular in the muscular fabric of the heart, with any tolerable degree of evidence; because it is the peculiar property of the fibres in the heart to join together in branchy appendices or heaps, in so strict union, that they cannot be separated without laceration.

But there are several eminent anatomists, whose ingenuity and communicative freedom deserve respect, who have represented and described those fibres displayed and separated: namely, the external fibres of the heart, common to both ventricles, descending to the tip, and then, taking another course, to insert themselves into the septum; others again, at the tip, to perforate the left ventricle, and return, in a contrary course, to the basis along the inner surface of the said ventricle. But the middle fibres, betwixt the aforesaid inner and outermost ones, being variously inclined towards the basis, form the septum. And others have given us figures and descriptions of still different orders of fibres, of which the outermost run counter to the innermost, while the intermediate are transverse. To the above description, says Dr Haller, as they are not much different from my own observations, I shall make no opposition, although I have never been able to see this disposition

disposition of them sufficiently manifest, and am acquainted with great anatomists who have not been more successful than myself.

These fibres of the heart, like other muscles, are furnished with *nerves* of their own, very numerous and of various origin.

That these nerves conduce powerfully to move the heart, is the opinion of eminent anatomists, from a consideration of the common nature of muscles; and from the increase which follows in the heart's motion, by irritating the eighth pair of nerves, either at the brain or the spinal medulla; and from the languor that ensues upon tying those nerves, which proves fatal, either suddenly or within a few days, even though you happen to make the ligature on but a few of the nerves that come to the heart; for the intercostal, and especially those from the ganglion of the upper thoracic, cannot be tied.

But that there are still other causes, besides that of the nerves, conducing to the motion of the heart, we are persuaded from observing its motion undisturbed by the irritation of all the nerves in the living animal; from its remaining after the greatest wounds of the head, and even of the cerebellum and medulla spinalis; likewise from its motion when torn out of the breast; chiefly in those animals whose lungs, being impermeable, make no resistance to the heart's motion; for the motion of the heart is observed to be very vigorous in the foetus before the brain is well formed, and likewise in animals wanting the head. And all our experiments agree in this, that the quiescent heart in dead or dying animals, when irritated by heat, vapours, poisons, and especially impelled flatus, watery liquors, wax, or blood, or on receiving an electric spark, immediately contracts itself, putting all its fibres into a rapid motion, by a force sometimes common throughout the whole heart, and sometimes affecting only a particular part of it.

Thus then we see, that there resides in the heart a kind of impatience of stimulus ; so that even in the viscus, when almost dead, wrinkles, and motions of different kinds, appear to be propagated along its surface, from places as it were irradiating from points : again, the heart, when torn out and cold, on being pricked, inflated, or irritated, contracts itself ; and its fibres, when dissected, corrugate themselves orbicularly, when there is neither nerve nor artery to bring it supplies of any kind. This irritability is greater, and remains longer in the heart, than in any other part of the body ; seeing, by stimulating it, the motion of the heart may be renewed at a time, when that of no other muscle can. The heart of the foetus is most irritable ; as well as larger, in proportion, than in adults ; and most tenacious of its motion, even in the cold. That motion is *peculiar to the heart itself* ; coming neither from the brain, nor the soul ; seeing it remains in a dead animal even when the heart is torn out of the breast ; neither can it, by any act of the will, be made either quicker or slower.

It is, therefore, evident, that the stimulus, occasioned by the impulse of the venous blood, causes the heart *to* contract itself ; and that this contraction is convulsive, made with great celerity, and a manifest corrugation of the fibres ; whereby the whole heart becomes shorter, thicker, and harder ; so that the left ventricle is drawn somewhat towards the septum of the heart, and the right one much more. The base also advances towards the apex ; but the apex more evidently towards the basis. (This Dr Haller has often observed with the greatest certainty in dissecting brute animals ; so that those learned gentlemen must have some way or other been deceived, who have asserted, that the heart is elongated during its contraction.) But the heart does not seem to turn pale in such animals as have warm blood. Even the septum of the heart is rendered shorter, and draws itself towards the basis. By this action, the
fleshy

fleshy parts of the heart swell inwardly, and compress the blood as they do the finger, when introduced into its cavities. But that the heart is accurately enough emptied in this action, appears from the event; the evident paleness of animals whose heart is white, as frogs and chickens; and from the internal surface being full of eminences, which exactly answer to opposite cavities, and to the thick reticular arms or columns interrupted by sinuses. And besides, the apex of the heart, being contracted a little like a hook, strikes against that part of the pericardium next the thorax. Forwards, there is also a pulsation from the left venal sinus; which is at that time particularly filled. In expiration, the heart strikes violently upwards and forwards. The truth of both these we know by experiment.

The blood, which is pressed by the contracted heart, endeavours to escape in all directions; but being driven from the muscular sides, towards the axis of the ventricle, by the reaction of what is lodged betwixt the venal ring and sides of the heart, the looser ends of the said ring are driven forwards and extended inward at the same time. By this action upon the whole circumference of the ring, it not only becomes extended itself, but, at the same time, rejects a part of that blood into the right auricle, which had before descended into the cone of the open valve, whose sides, now approaching, shut up the venous orifice more closely as the heart contracts more strongly; by whose force the tricuspid valves, as they are called, would be pressed reduplicated into the auricle, if the muscular nipples or columns did not keep down their edges, and hold them firmly by their contraction (which is the same with that of the heart) in such a shape as will extend the annexed cords of the valve, without injuring them.

But the nîsus of the remaining blood, now resisted by the tricuspids, seeks another course; and whilst the larger of those valves that is seated to the right, advances from the side towards the axis of the heart, this
leaves

leaves open the mouth of the pulmonary artery, which it before covered; whereupon the blood pressing the valves in the mouth of the said artery close to its sides thus rushes into it.

Each of these valves, in conjunction with the sides of the artery here diverging, intercepts a space, which is blind or impervious downward, but open upward in a parabolical shape, as we shall find in the valves of the veins. When, therefore, the blood is impelled from the sides towards the axis of the contracting heart, it endeavours to escape in the direction of the said axis; and, by rushing forth like a wedge, betwixt the valves, presses their loose sail-like edges against the sides of the pulmonary artery, so as to run freely out of the heart. The truth of this appears from the fabric, from injections, and from ligatures, which, by obstructing the lungs, will not suffer the large cavities in the right side of the heart to be emptied.

The blood now received into the pulmonary artery, goes on then to make its circulation through the lungs. That artery is first divided into two branches; of which the left, being less and shorter, enters directly into the substance of the lungs: but the right branch, being larger and longer, passes transversely through the arch of the aorta; and, after going a little way behind the said aorta, enters the corresponding lungs of the same side. From each of these branches, by a multiplied subdivision, arise the very least arteries; some of which transmit the blood directly into the continued small veins, and others exhale part of its aqueous juices into the pulmonary cells. That the blood goes thus directly from the arteries into the pulmonary veins, appears evidently from their structure; also from a ligature, which intercepting the blood's course, while the heart and lungs still urge it, causes an aneurismatic dilatation of the artery; and from polypuses, by which, the mouth of the pulmonary artery being obstructed, the right cavities of the heart become monstrously enlarged, and

at length burst, while the left remain empty. Lastly, from injections; for water, fish-glue, and milk, are very easily forced from the pulmonary artery into the vein, and from thence into the left cavity of the heart. But the direct anastomoses or final openings of the arteries into the veins in the lungs, is proved even to the sight by the microscope, in frogs, &c.

Nor can the blood which has once entered the pulmonary artery return back again upon the heart; because the valves therein are of such dimensions, that when distended, they perfectly shut up the opening at the heart; and are so strong that they resist a much greater force than the contraction of the pulmonary artery, without being constrained to yield. However, sometimes, from a greater contractile force of the artery, they grow somewhat callous; or, from a laceration of their outer membrane, a bony matter is poured in betwixt the duplicature of the valves. For, when the blood, by the contraction of the artery, returns towards the heart, it meets and enters the open sail-like concavities of the valves, which are by that means expanded, and driven together towards an axis in the middle: whence the valves, once expanded, quite shut up the mouth of the artery, so as to leave not the least slit open; for any opening that might be left, is precluded by the small callous bodies remarked in the middle of the valves.

The *pulmonary veins*, of which we shall say more hereafter, gather into larger branches, which at last terminate in four (seldom two, and still more rarely into five) trunks; to which it has been customary to affix a name in the singular, by calling them the *pulmonary vein*. These enter the cavity of the pericardium, from whence they receive an external covering; and are then inserted at angles into the square left or posterior sinus, which is sometimes likewise called the *pulmonary sinus*. In this course the upper veins descend as the lower ones ascend. But that these veins bring their

blood towards the heart, in the same direction with the sinus into which they open, is proved by a ligature, which causes a turgescence or swelling, from the blood retained, betwixt the ligature and the lungs.

In this left sinus, the blood waits for the heart's relaxation; at which time the nifus of the blood impelled against the venous valves, and the contracting stronger force of the sinus, grow less. Then the left sinus stretches itself forward across the heart, is contracted transversely along with it, and the appendix becomes evidently shorter and narrower. Thus the blood is driven into the left ventricle, in like manner as the right auricle impelled its blood into the right ventricle. For here, as before, a like membranous oval ring forms productions called *mitral valves*, of which there are usually two only counted. These valves are longer and stronger than those of the right ventricle. They have each its own and separate muscular structure; but it is much firmer than that of the tricuspid. And here, more often than in the valves on the right side, we find cartilaginous tumors in the tendinous strings, produced by the friction occasioned by the great motion of the heart.

From what has been said then, it appears that the same blood is now arrived into the left ventricle of the heart, which was a little before sent from the *venæ cavæ* into the right auricle, which drove it into the corresponding or right ventricle; by which again it was urged into the pulmonary artery; and from thence passing into the pulmonary veins, was conveyed into the left sinus; and out of this we here find it driven into the left ventricle. This course of the blood, from one side of the heart to the other through the lungs, is called the *pulmonary* or *lesser circulation*, and was known to many of the ancients. It is proved by the increased bulk of the pulmonary veins on the left side; and likewise of the right cavities of the heart, from

from an obstruction of the entrance into the left ventricle.

The *left*, or posterior and upper *ventricle* of the heart, which is always first formed, and in a great number of animals the only one, makes up that part of its half cone-like body, which we before called *obtuse*. It is somewhat narrower than the right ventricle, a little longer, rounder, and generally of a less capacity within, says Dr Haller : for the contents of this ventricle are about two ounces, while those of the right approach to three. Its fabric internally is reticular, but more nicely wrought than in the right ventricle ; and within the mouth of the artery it is smooth : but its force is considerably greater, as the muscular flesh that surrounds it is much thicker and almost three times stronger. The septum of the heart belongs mostly to the left, but some part of it also to the right ventricle : the whole of it is reticulated in like manner ; but solid, and incapable of suffering any injected liquid to pass from one ventricle to another.

Again, this left ventricle being instigated to motion by the impelled blood, does, from the same irritable nature already mentioned, contract, and drive its contained blood with a violent motion in the direction of its axis, and determine it towards the basis, at the time when the tip or cone of the heart is drawn nearer to its basis. And since the apparatus of the mitral valves is here the same as in the tricuspid, the venous blood now expanding the ring from whence they arise, removes that valve which lay against the mouth of the aorta, so as to open a way for itself to the artery ; in dilating the mouth of which, the said blood presses the semilunar valves, there placed, against the sides of the aorta, into which it rushes with a violent impetus. This is proved by ocular demonstration in living animals, where the left ventricle swells upon shutting the passage into the aorta.

The *semilunar valves of the aorta* differ little from those

those in the pulmonary artery: only as the opening is here greater, so the valves are proportionably larger and stronger, and are not so often found to want those callous round bodies in the middle. The fibres too of the valves, both transverse and ascending, are here somewhat more conspicuous.

After the contraction of the heart, follows its relaxation or diastole, in which it becomes empty, lax, and soft, recovers its former length, the ventricles recede from the septum, and the basis from the apex. But, while it is in this state, the blood in the auricles, having been as it were in a state of expectation, rushes through the openings of the valves of the veins, dilates the opposite sides of the heart, and makes it at once longer and larger. After the auricles have freed themselves of the blood they contained, they are in like manner relaxed, and their opposite sides remove from each other. Then the blood collected in the venæ cavæ and pulmonary veins, fills the auricles by the contraction of the veins; renders them long, broad, and thick, like the ventricles; and even distends and fills the tooth-like processes of the crested margin. That the fibres of the heart are not dilated, is proved from the junction of those fibres; which, being tied together by their middle branches, cannot be separated: also, by the dissections of live animals, in which the whole heart is shown to be contracted.

But we must now consider, that these motions of the right and left auricle, with the right and left ventricle, are not performed in that succession in which, for the sake of method, we have here described them; for both the auricles are contracted, while the ventricles are relaxed: so that the contraction of the auricles precedes the contraction of the ventricles; as we are assured from manifest experiments on dying animals, and on those whose living blood is cold. But both auricles are filled together in the first instant, as both of them are emptied together in the second instant; and

and both the ventricles are contracted together in the third instant, which is the same with the first; and both ventricles being evacuated, are relaxed in the fourth instant, which is the same with the second. Those who have inadvertently taught otherwise, have not taken the advantage of making a sufficient number of experiments on living animals. That the auricle, near death, makes frequent palpitations before the ventricle of the heart performs one contraction, is true enough. The auricle with its sinus forms one cavity, and both are filled and both emptied in the same instant.

But it may be asked, Why the heart never ceases from its perpetual motion through such a number of years as there is in one's life, through so many days as there are in a year, and through so many hours as there are in a day; when in each hour the heart of a healthy person contracts not much less than 5000 times; so often are there successive repletions followed with new contractions, perpetually in the same constant order; nor is there any muscle, besides the heart and diaphragm, but what becomes tired and painful, by acting incessantly, even for a few hours? Different answers have been given to this question by different professors, founded either upon a compressure of the cardiac nerves betwixt the large arteries, or upon an alternate repletion of the coronary arteries and cavities of the heart, &c.

But to Dr Haller the simplicity of nature seems very great in this matter. When the auricle is relaxed, it is directly filled by the muscular force of the continuous great vein; and so the heart also contracts itself, when it is irritated by the blood driven into it from the auricle. Therefore the heart having once received the blood, is contracted by that stimulus, or irritable force, whereby muscular fibres are excited into contraction; whereupon it empties itself of the blood; and being freed from the stimulus thereof, im-

mediately rests or relaxes itself. But the heart being now relaxed, the auricle is in like manner irritated by its contained blood, and by contracting fills it again; while the incessant actions of the heart and arteries continually urge new blood into the right sinus and auricle. That this is the true state of the heart's motions, is proved from actual experiment or observation; whereby we plainly discern the successive repletions and contractions made in the great vein, auricle, ventricle, and artery, easily seen in a weak or expiring animal; but more especially, and more evidently, in those animals which have but one ventricle in the heart; as the tortoise, frog, snake, fishes; and in the chick hatching in the egg, which, instead of a heart, has only one crooked canal. Besides, it is confirmed from the inertia of the heart, produced by tying the veins; and from the return of its motion, when the ligatures are unloosed; provided these phenomena are sufficiently valid: but this is more unequivocally corroborated by injection, and by the perpetual contraction of a frog's heart, from the inflation of a bubble of air, which many hours it alternately ejects and receives into the auricle. The left ventricle first ceases its motion; then the auricle of that side; then the right ventricle; after that the right auricle; and, last of all, the pulmonary veins and *venæ cavæ*. Whatever motion is in the *venæ cavæ*, ought to be attributed to the auricle repelling the blood into both these veins, and which the heart, when dead, is not capable of receiving.

Nor does Dr Haller believe there is any thing more required to the heart's motion than a continual stimulus applied to a very irritable part. For, just upon the approach of death, the very coldness of the limbs, which the warmth of life has left, contracts the veins, and drives the blood to the heart; when the lungs, being impermeable for want of respiration, transmit no blood to the cavities of the left side. And, on the other

ther hand, the heart, after it is thoroughly emptied, remains at rest. It may thus happen, that, instead of the vena cava and right auricle, the last appearance of life may be transferred to the left auricle and ventricle; if we suppose the right cavities to be emptied, the left may be irritated by the blood contained in them. But if you derive the resting of the heart from the compression of its nerves, the motion of the auricles will be an objection, because their nerves are not compressed. An example also we have in fish, and little chicken in the egg, where there can be no room for a compressure of the nerves. If, again, you deduce the heart's rest from a compressure of the coronary arteries, this is contrary to experience; since they are not covered by the valves of the aorta, and from a wound of the said arteries, during the systole of the heart, the blood starts out to a great height.

Nor with the strength of the heart does Dr Haller join the oscillations of the very small vessels, which is refuted by experiments: nor the force of external heat; seeing animals are found to live and thrive in the coldest regions of the north: and though the contractile force of the artery, and the weight of the parts and of the atmosphere, assist the motion of the blood during the diastole of the heart, the same powers resist it during the systole; so that, indeed, by these means the blood is moved no farther through the contractile arteries, than through the rigid arteries of smaller animals.

But with what celerity, and with what force the heart drives forward the blood, is controverted and variously computed. The more modern writers have raised their calculations upon a supposition, that, for the celerity to be determined, we are to admit two ounces of blood to issue out of the heart with such a celerity, that the part of the pulse called its *systole*, makes one third of the whole pulsation, and is finished within a $\frac{1}{15}$ part of a minute; but the area of the mouth of the aorta,

they have estimated 0.4187 parts of an inch: so, by dividing the space filled by two ounces of blood, (3.318 inches) by the area or section of the aorta at its mouth [and length of its cylinder filled by two ounce. viz. $= 7\frac{1}{11}\frac{1}{11}\frac{1}{11}\frac{1}{11}$], the number thence produced divided by $\frac{1}{11}$, the time in which the heart contracts, they find 149 feet and two-tenths of an inch for the space through which the blood runs in a minute, if it goes on in a cylinder with the same velocity it first had from the heart. But the incumbent weight of blood moved by the heart, they have computed by the jerk wherein the blood starts forth from the larger arteries in a living animal, being seven feet five tenths; and from the surface of the ventricle, whose area makes 15 inches. Thus 1350 cubical inches of blood, or 51 pounds five ounces, circulate, which press against the ventricle of the contracting heart. The heart, therefore, thus drives forward a weight of 51 pounds with a velocity by which it may run through 149 feet in a minute; which force it exerts four thousand eight hundred times in an hour.

Although there are many particulars here unthought of which may render the estimate incomplete, and such perhaps as we may never ascertain; and although the mouth of the distended aorta may be wider in a living animal, though the area of the ventricle is of uncertain dimensions, and the jerk of blood computed from an insufficient height; yet if we consider the violence with which the blood starts from some of the least sanguine arteries in the living animal, although we cannot easily determine how much of the heart's systole is thus spent, variations in which will greatly alter the computation; yet, in the mean time, it will plainly appear that the machine we call the *heart*, is a very powerful one. The truth of this is evident from experiments; in which it appears to be very difficult to fill all the red blood-vessels by anatomical injections, and quite impossible to fill all the smaller ones; yet the

the heart, we see, not only gradually distends all the larger, the smaller, and even the least vessels, with blood, but also drives it forward through them with a considerable celerity. Even in the least arteries, the blood is urged forward by the heart with such a force as to make the alternate motions of that muscle perceptible. Likewise, in the veins and smaller vessels of cold animals, even while contained in the insect's egg, there is no other force besides that of the heart, by which the blood is driven through their small vessels. And, from some of the least arteries, I have seen the blood start forth several feet, the jerk describing a parabola, whose height was four feet, and amplitude of projection seven feet; and some assert, they have seen the blood ascend from the aorta to the height of twelve feet.

Moreover, that we may make a just estimate of the heart's force in living animals, we must consider what great resistances that complex muscle overcomes: we must compute the enormous weight there is of the whole blood; a mass perhaps of fifty pounds and upwards: for all that quantity of fluids, once stagnant in a person lately drowned or fainted away, are easily put into their former motion by the heart only. We must again consider the great decrease of the blood's velocity, arising from the greater light or capacity of the dividing branches (from whence the ratio of its celerity, even in the intestines, may be computed to only a 24th or a 30th part of its original impulse), abates two-thirds from the heart's force. And yet we see there are humours swiftly moved through the most minute vessels; as, for example, the Sanctorian perspiration, which in a subterraneous cavern I have observed to ascend swiftly in form of smoke or vapour; and the same celerity of the blood in the least vessels of little fishes, &c. is apparent to the eye by a microscope. Now, since the frictions in every machine always consume the greatest part of the moving forces; much more do they

they in the human body, whose blood and juices are so much more viscid or clammy than water, and driven through vessels so small, that they permit a globule only at a time to pass through, and even hardly allow that without changing their figure: but from so strong and extended a friction there must necessarily follow a very great hindrance to the motion; whence we may easily understand, that the force must be very great, which drives so swiftly such a prodigious mass of fluids in spite of so many resistances and decrements of the moving forces. But, more than that, aneurisms and arteries are burst, and very great weights, as well as the body itself, raised, by the force of the heart's systole.

The blood, being driven into the aorta, immediately finds the two openings of the coronary arteries, which lie next the arterial valves, but above them, or within the aorta; and in consequence of this, it rushes first of all into the said coronary arteries, by which the heart supplies itself with blood. These arteries are for the most part two; the right goes off between the aorta and pulmonary artery, and the upper and left one between the left auricle and the aorta. All the external arteries are surrounded with much fat; but their cavity is more intercepted with valves than that of other arteries. These arteries communicate, by inosculations of the small branches, every where about the septum and tip of the heart; but they no where make a complete ring round the heart. They terminate in a two-fold manner.

The first termination of them is into the coronary veins, whose branches running in company with those of the arteries, have their trunks of necessity disposed in a different course.

There are some who will have the coronary arteries filled with blood, not by the contracting of the heart, but of the aorta in its systole; which they think must be a consequence of the retrograde angle of the blood's course here, and the paleness of the contracted heart,
with

with a supposition that the valves of the aorta cover or close the mouths of the coronary arteries. But the two last of these are disproved by experience; and the first, or retrograde course, can only impede or lessen, and not intercept, the flux into the heart: for the injections of wind or mercury into all the seminal and biliary vessels, demonstrate that the large retrograde angles, which the vessels often make there, do not hinder the fluids from taking, though they retard, their natural course. But a proof, still more evident, is, that the coronary artery has a pulse at the same time with all the other arteries in the body, and the blood starting from it makes a higher saltus at the time when the heart is contracting.

The circulation through the coronary vessels seems to be completed in the shortest space of time that can be necessary in any part, from the great velocity the blood receives from the heart itself, urging the same through its own substance. But that the whole contents of the vessels are cleared in each contraction, does not seem probable; for the blood-vessels of the heart do not look pale enough in that action to produce such an effect as an entire evacuation. There is a very free or open passage from the arteries of the heart into the cellular substance, or fat which surrounds it. If you ask, What are the uses of those least or shortest veins which open obliquely through the surface of both the ventricles? they serve to return the blood of those deeply seated small arteries, which have no corresponding veins.

The humours of the heart, which are thinner than blood, return by the valvular *lymphatic veins*, which accompany the coronary blood-vessels, and ascend towards the thoracic duct and subclavian vein; but they are to be very rarely seen, although they can be distinctly observed in brute animals.

§ 7. *Of the Nature of the Blood and Juices of the Human Body.*

THE liquor which is contained in the beating arteries and their corresponding veins, is called by one general name, the *blood*: which, to a loose examination, appears homogeneous, or of similar parts, red and coagulating throughout; and is observed to be redder in proportion to the strength of the animal: in a weak and famished one, the blood inclines to a yellow: it hath a whiteness mixed with it, which comes almost totally from the chyle. But from various experiments it is certain, that this animal liquor contains very different ingredients.

That fire is contained in the blood may be proved from its heat, which, in human blood, and that of some other animals, is from 92 to 100 degrees of Fahrenheit's thermometer, which is more than the mean degree of atmospherical heat, but less than the greatest. "The heat (says Dr Wrisberg), which all perfect animals peculiarly possess in by a far a greater degree than vegetables, from the more simple class of animals, through the various orders of fishes, amphibia, man, quadrupeds, and birds, at length gradually increases, till for the most part, in a natural state, even at its greatest heat, it does not exceed the 110th degree of Fahrenheit. Daily experience shows, that it differs in man, according to age, temperament, state of mind, motion, or rest of body, climate, weather, kind of life, meat and drink, health, and the various species and violence of disease. It is also certain that the degrees of heat in the body increases a little from an augmentation of heat in the atmosphere: but it does not rise to the greatest pitch of summer-heat, although we can live in a much greater heat; as is proved by persons employed in sugar-houses, melting furnaces, by mowers, and the use of baths and stoves in Finland and Russia; and also by the late experiments of Fordyce, Blagden,

Blagden, Hunter, and Dobson. It is sometimes so diminished in an intense cold, that in a person frost-bitten, but not dead, a thermometer applied to the mouth, arm-pits, groins, and even the vagina, would not rise above 76° of Fahrenheit. But is the matter of heat in the blood alone? It is sufficiently probable from phenomena; since the heat of the body is diminished by hemorrhagy, or when the blood is intercepted by ligature and compression from reaching the joints, it being restored when the blood returns. I must observe, however, that my experiments on living animals, particularly upon swine, did not discover so great a difference as might be expected, between the heat of the heart, the arteries, veins, brain, stomach, intestines, tunica vaginalis, and even the interstices of the cellular texture in the muscles." Again, a kind of volatile vapour or exhalation continually flies off from the warm blood, with a sort of fetid odour intermediate betwixt that of the sweat and urine. This vapour, after collection and condensation in convenient vessels, partakes of an aqueous nature, with somewhat of an alkaline quality.

After this vapour has dissipated, the blood of a healthy person spontaneously congeals into a scissile trembling mass; and with a less degree of heat than that of boiling water, (viz. 150° deg.) This toughness is greater in feverish persons than in such as are in health. It sometimes coagulates in the veins of a living person, and is found clotted in wounds of the arteries. But even within the vessels of a living person, and in one dying of a fever, the blood has been seen, by the violence of that distemper, changed into a concreted tremulous jelly throughout all the veins. The principal part of this coagulated mass is the *crassamentum* or *cruor*, which has the red colour peculiar to itself, and gives it to the other parts of the blood. This, if it be not kept fluid by the attrition of a vital circulation, or some similar concussion, runs confusedly into a compact, but soft

soft mass, like liver, merely by rest and a moderate degree of cold; as it also does by the addition of alcohol, by mineral acids, or by a heat of 150 degrees, of which 98 is the blood's heat in robust people. It is, either as a fluid or a solid, specifically heavier than water by near an eleventh part; and, when freed from its water, it is wholly inflammable. In a mass of healthy blood, one half or upwards is red cruor: and, in strong laborious people, the serum makes only a third part; and is still more diminished in fevers, often to a fourth or fifth part of the mass.

Another white, somewhat yellowish part of the blood, separates from this coagulum, transuding, as it were, through its pores, and at last becomes a quantity, in which the coagulum sinks: this again seems, though not really so, a homogeneous liquor. This part of the blood is, in general, one thirty-eighth part heavier than water, and almost a twelfth part lighter than the red globular mass of crassamentum: this too, by a heat of 150 deg. or by mixture of mineral acids or alcohol, and by a concussive motion, is coagulable into a much harder mass than the red cruor; and forms an indissoluble glue, a flesh-like membrane, which at length shrinks up to a horn-like substance, or friable gum. From thence are formed the pleuritic crusts or skins, polypuses, and artificial membranes. Besides this coagulable albumen, simple water, of which there is the greatest portion, is latent in this serum; and likewise a quantity of mucus, less capable of being drawn into threads than the red cruor; nor at the same time coagulable, like the albumen, by heat and acids. Hewson has discovered a second kind of lymph, which Krausius has also allowed; but this does not hurt the received opinion of the elements of the blood.

But by putrefaction only, or the dissolving power of the air hot to 96 deg. equal to the blood's natural heat, the whole mass, but especially the serum, dissolves or melts into a fetid liquor; first the serum, and then the
cruor

cruor more slowly ; till at length the whole mass, both of serum and cruor, is turned into a volatile and fetid exhalation, leaving very few feces behind. The blood being a little dissolved by putrefaction, and even before that, becomes fetid ; with the fætor it assumes an alkaline nature ; and effervesces with acids. This property it afterwards loses, the alkaline salt being destroyed by putrefaction. The putrid blood cannot by any art be inspissated, as it is also very difficult to be resolved after it has been coagulated by spirit of wine. By too severe exercise, heat, and malignant disorders, the cohesion of the blood is dissolved, and it assumes an alkaline nature almost as if from putrefaction.

Besides these parts of which the blood appears to consist, without subjecting it to any violence, it contains in its substance a quantity of *sea salt*, which is discernible to the taste, and sometimes visible by the microscope. That there is *earth* in the blood is demonstrated from nutrition ; and from a chemical analysis, whereby the earth appears to lodge in the most fluid, and especially in the oily parts of the blood. By some very late experiments, it appears, that a considerable quantity of ferruginous earth, easily reducible into metal by the addition of phlogiston, is contained in the blood when calcined. Lastly, another part in the blood is *air* in an unelastic state, and that in a very considerable quantity ; the existence of which air in the blood and serum is proved by the putrefaction and distillation, or by removing the ambient air from them by the pump. But we are not to think, from hence, that the blood-globules are bubbles full of air, for they are specifically heavier than the serum.

By the admixture of neutral salts the colour of the blood becomes deeper and brighter, without being either dissolved or thickened. It is scarcely altered by a weak acid. By fermented liquors it is coagulated. Fixed alkaline salts have almost the same effects as the neutrals. The volatile alkalis rather turn it brown,

and coagulate it. Alcohol and distilled oils, and likewise vinegar, coagulate it. It does not effervesce with any salt.

Chemistry has, in various ways, showed us the nature of the blood. (1.) When fresh drawn, before it has time to putrefy, the blood, distilled with a slow heat, yields a *water* to the quantity of five parts in six of the whole mass; which water has little or no taste or smell till you come towards the end of the operation, when it is proportionably more charged with a fetid oil. (2.) The residuum exposed to a stronger fire, yields various alkaline liquors; of which the first, being acrid, fetid, and of a reddish colour, is usually called the *spirit* of blood; consisting of a volatile salt, with some little oil, dissolved in water to the amount of one twentieth part of the original mass of blood. There is an acid observable in the fat, and likewise in putrid flesh and blood. (3.) A little before, and together with the oil, that next ascends in the distillation, dry *volatile salt* arises, and adheres in branchy fleeces to the neck and sides of the glass; and this in but a small proportion, less than an eightieth part of the first mass. (4.) The next liquor is that called *oil* of human blood, which ascends gradually thicker and heavier, and is at first yellow, afterwards black, till at last it resembles pitch, being very acrid and inflammable, but in a small quantity, about a fiftieth of the whole mass. (5.) There now remains, in the bottom of the retort, a spongy inflammable coal or cinder of the blood; which, being kindled, burns away, and leaves ashes behind. From these, by lixiviation with water, is obtained a *mixed salt*, partly sea-salt, and partly fixed alkali, together with a small quantity of fixed earth. This fixed salt is scarce the five hundredth part of the first mass, and of this only one fourth part is alkaline: but being urged with the most intense degrees of fire, the whole salt affords some portion of an *acid spirit*; which we judge to arise

partly from the sea-salt in the blood; some of which is demonstrable even in the spirit of blood; and partly from the vegetable kind of the aliments, not yet digested into an animal nature. For which last reason, an acid is procurable from the blood of graminivorous animals as well as from that of man. But the *earth*, separated from the lixivium by filtration, will, perhaps, make about an hundred and fiftieth part of the original mass; and contains some particles which are attracted by the loadstone.

From the preceding analysis of the blood, it evidently contains a variety of particles, differing in bulk, weight, figure, and tenacity; some watery, others inflammable, and most of them inclined greatly to putrefaction or to an alkaline nature. For the blood, in a sound healthy state, not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid; but mild or gelatinous, and a little saltish to the taste: yet, in some diseases, it is sharp enough, and comes near to a state of putrefaction; as for instance, in the scurvy, where it corrodes its containing vessels; and in dropsies, the waters of which are often next to alkaline. But an alkalescent calx is found in the blood of insects, which effervesces with acids.

By viewing fresh blood in a small glass tube by a microscope, or by applying the same instrument, while it is yet moving in the veins of a warm living animal as a hen-chicken, or a cold one as a frog, we perceive in it red globules; which, doubtless, make that part called *cruor* or *crassamentum*. If it be questioned, whether these are not rather lenticular particles of the same kind with those observed by Leuwenhoek in fish, and lately discovered in our own species, we confess it is a point difficult to determine: Hewson, however, observes, that the particles are flat like a guinea. (See his Treatise on the Blood.)

The colour of these globules is red; and so much the deeper and more inclined to scarlet the stronger

the animal is : and in the same proportion their number increases, when compared with the quantity of yellow serum. Their diameter is very small, being between $\frac{1}{1000}$ and $\frac{1}{700}$ of an inch. They are said to change their figure into an oblong egg-like shape, which Dr Haller could never observe with sufficient certainty. They are also said to dissolve into other lesser globules of a yellow colour, which he had neither observed himself nor can easily admit.

From the red part of the blood, fibres are generated in abundance ; from the serum, in smaller quantities. They are procured by pouring the blood into a linen cloth, and washing it gradually with a great deal of water, or by beating it with a rod. In quantity, they equal the 28th part of the whole mass. These are formed of the gluten, and are not generated in a living animal ; seeing they are neither to be perceived by the microscope, which so easily renders visible the red globules, nor yet does their long thread-like figure seem adapted for receiving motion.

From the preceding experiments compared together, arises that knowledge which we at present have of the blood ; namely, that the crassamentum or cruor is composed of globules. The inflammable or combustible nature of these globules is proved from dried blood, which takes flame and burns ; as also from the pyrophorus, which is generated from the human blood : and from these most probably arises the greater part of the pitchy oil that is obtained from blood by the violence of fire.

The serum of the blood distilled with a strong fire, gives over almost the same principles with the cruor, viz. salt, oil, and earth. It yields, however, much more water, but no iron at all. Similar principles, but with a less proportion of oil and salt, are obtained from the aqueous humours prepared from the blood ; as the saliva and mucus.

The exact mass or quantity of blood contained in
the

the whole body cannot be certainly computed. The weight of the mass of humours, however, is much greater than that of the solids; but many of them do not flow currently in the circulation, as the glue or jelly that lodges in most parts, and the fat. But if we may be allowed to form a judgment from those profuse hemorrhagies that have been sustained without destroying the life of the patient, with experiments made on living animals by drawing out all their blood, joined with the bulk of the arteries and veins themselves: from these principles, the mass of circulating humours will be at least fifty pounds; of which about 28 will be true red blood, current in the arteries and veins: of which the arteries contain only four parts, and the veins nine.

Nor does the blood always contain the same, or a like proportion, of those elements or principles above mentioned: for an increased celerity, whether by laborious and strong exercises, a full age, fever, or otherwise, augments the crassamentum, with the redness, congealing force, and cohesion of the particles; and the hardness and weight of the concreted serum with the alkaline principles, are by the same means increased. On the other hand, the younger and less active the animal, and the more watery or vegetable the diet on which it is fed, the crassamentum of the blood is proportionably lessened, and its serum and mucus increased. Old age, again, lessens the crassamentum and the gelatinous part likewise.

From these principles, but with a conjunct consideration of the solid fibres and vessels, the different temperaments of people are derived. For a *plethoric* or *sanguine* habit arises from an abundance of the red globules; a *phlegmatic* temperature from a redundancy of the watery parts of the blood: a *choleric* disposition of the humours seems to arise from a more acrid, acid, and alkalescent property of the blood; as appears from those who live on flesh and on the human

R 2

species,

species, being so much fiercer and more passionate than those who live on plants or on vegetable food. In the solid parts, a great firmness joined with an exquisite sensibility, or nervous irritability, disposes to a choleric habit; a less irritability, with a moderate density, to a sanguine habit; and a lesser degree both of density and irritability are to be referred to a phlegmatic temperament. There is also a kind of dull heavy temperament, in which there is the greatest strength of body, joined with no great degree of irritability. In the melancholic, again, a weakness of the solids is joined with the highest degree of nervous irritation or sensibility. But you must be careful not to take these temperaments as the sole and limited systems or classes of constitutions; which, in the course of nature, are found to be not only four, or eight, but are really distinct in numberless degrees.

The red part of the blood seems chiefly of use to generate heat, since its quantity is always in proportion to the heat of the blood. This being confined, by the largeness of the globules, within the red and first order of vessels, hinders them from collapsing: and, in receiving the common motion of the heart by the greater density of its parts, it has a greater impetus, and sets in motion the lesser orders of humours. Nor is it improbable, that the heart is more strongly irritated by the ponderous cruor of the blood. The globular figure of its parts, together with their density, makes it easily pervade the vessels; and the quantity of iron it contains, as well as of oil, perhaps increases its power of generating heat. And hence it is, that the red part of the blood being too much diminished by profuse bleedings, there follows a stagnation or lessened motion of the humours in the smaller vessels; whence fatness, and dropsy. By the same rule also a due proportion of cruor is necessary within the habit, to generate and repair new blood. For, by large hemorrhagies, we see the blood loses its red or dense

dense nature, and degenerates into a pale, serous, or watery state.

The coagulable serum is more especially designed for the nutrition of the parts, as will be hereafter more apparent. The thinner juices serve various purposes; as the dissolution of the aliments, the moistening of the external surface of the body and surfaces of the internal cavities, to preserve the flexibility of the solids, and conduce to the motion of the nerves, the sight, &c. The saline particles seem proper for dissolving the aliment, and stimulating the vessels. The properties of the aërial part are not yet well known. The heat occasions the fluidity, and is not easily raised to such a degree as to coagulate the humours.

Therefore health cannot subsist without a dense and red blood, whose quantity too much diminished causes a stagnation of the juices within the smaller vessels; whence all parts of the body become cold and weak. Nor can life or health subsist without a sufficiency of thinner juices intermixed with the red blood; seeing the cruor, deprived of its watery part, congeals, and obstructs the smallest passages of the vessels, and kindles too great a heat.

If it is asked, Whether there be any difference betwixt the arterial and venous blood? we answer, That some difference seems to happen; the former having lately suffered the action of the lungs. But, in experiments, I scarce find any observable difference either in colour, density, or any other known diversity. Sometimes, however, I have found a most evident difference; for the bright colour of the arterial blood seems to distinguish it from the dusky dark-coloured blood in the veins; but this, in the plain example of the hatching of a chicken, arises only from the deeper series of globules in the thicker vein. But we have not sufficient certainty of a difference in the blood of different arteries. However, the arterial blood is apparently of a more bright or splendid red, and having a great-

er degree of fluidity and proportion of watery parts, may so far differ from the venous darker coloured blood. But to clear up this, farther experiments are requisite.

From one and the same mass of blood, driven into the aorta, are generated all the fluids of the human body; which, from their affinity one to another, are reducible to certain classes. The manner in which they are separated ought to be accounted for by the fabric or mechanism of the glands themselves. But we must first consider what the blood suffers from its containing vessels.

“ The theory of the temperaments of the human body (says Dr Wrisberg), in the sense commonly received by physicians, and taught in the schools, the received division of them into four species, and their repeated production from the different nature and mixture of the blood, favours too much of the ancient and particularly of the Galenical doctrine. I think there can be no doubt, that there are temperaments; and that the manner and rule which nature follows in man, and likewise perfect animals, may be observed in the performance of the corporeal and mental functions, in either preserving or endangering the health and life, and in the exercise of most of the duties and affairs of life, and in the actions of the internal and external parts, which are more or less connected with the safety of the animal. If, therefore, one would wish to give any specific name to this different relation and determination of the parts of our body, when once communicated with the system in general, as you would do to any plant, or other particular natural body, and to keep the ancient denominations sanguineous, choleric, phlegmatic, and melancholic, in preference to all others, he must be aware, that neither the various habits nor temperaments of mankind can originate solely from the different nature of the blood,
nor

nor all be comprehended under these four modifications.

“ With respect to the causes of diversity of temperament, there are many which co-operate. (1.) The various quantity, firmness, and sentient faculty of the nervous system, from the brain communicated to each nerve. I have always observed a choleric, and choleric-sanguineous disposition, in all persons having a large brain and thick strong nerves, along with a great sensibility as well of the whole body as of the organs of sense. Hence arises a ready apprehension of objects, and an increase of understanding and knowledge, and, owing to the comparison of many ideas, an acute and entire judgment, which choleric persons possess in so eminent a degree: but along with this condition of the nerves, they are excessively liable to grief and anger, when the body or mind is but slightly affected; and on this account medicines should be cautiously given, and less doses prescribed to them. With a small brain and slender nerves, I have observed the senses more dull, and a phlegmatic or phlegmatico-melancholic torpor conjoined. Therefore they require from external objects stronger impressions upon the organs of sense, and longer applied, if they are meant to leave lasting effects: hence their judgment is frequently weak on account of the defect of ideas; and they seldom acquire any extensive knowledge: but nature has compensated these disadvantages, by making them more able to undergo hardships from change of climate, life, or labour; they demand more powerful medicines and larger doses. What a great difference in man and the cetaceous animals! (2.) The various degrees of irritability in the muscular parts. For wherever you find a very delicate irritability, affected by almost every stimulus, and retaining lasting impressions, and at the same time acting with a certain celerity; in that case you cannot doubt of a choleric disposition: hence that remarkable strength in the

muscles of some persons, which acts with so incredible quickness, dispatch, and constancy. On the contrary; if you examine a phlegmatic person, you observe the contractile power of the muscles languid, difficultly yielding to stimuli, unless powerful; since the muscles of phlegmatico-melancholic men are long of being determined to motion, although strongly excited, and finish it with an appearance of languor. (3.) Even a certain softness is observable in all fibres and membranes, if you touch the body of a phlegmatic person; or a seeming hardness and dryness in melancholic habits: along with which particularities the phlegmatic join less elasticity, whilst in the melancholic there is a greater tone and contractile power. (4.) There is in the air, undoubtedly, a certain electrical principle, which being by respiration communicated in different ways with the body, imparts a natural tone to the fibres, occasions a quicker motion in the vessels, and increases and diminishes by turns the alacrity of the mind. But as this principle of atmospheric air does not prevail in equal quantity every hour of the day, all times of the year, and in every climate; so sometimes we feel an universal lassitude, which suddenly ceases, the strength of the body and mind being restored with a serene and elastic air; so in like manner all men do not equally absorb this electric matter, which thus forms a remarkable diversity of temperament. (5.) We ought too to combine with these the various nature of the blood from the proportion of the elements: and in fact, as greater stimuli in the blood excite the heart to brisker contractions; so a more acrid and copious bile may effectually promote the peristaltic motion, and the abundance of mucus occasion a tendency to lentor and frequent catarrhs.

“ Now, we see we have sufficient causes, which from our birth may bring on, in the first growth of the parts of the body, an irrevocable determination to
this

this or that habit or temperament. I therefore can scarcely admit a complete transmutation of temperament, which, during the exercise of these natural laws, could render a purely choleric person phlegmatic: But that some change may take place in temperaments, that violent attacks may be mitigated, that lentor, torpor, and listlessness may be increased, I readily agree; and from the remedies by which such a change may be produced, I form a second class of the causes of temperaments. The chief are, (1.) A different kind of meat and drink. An animal diet adds a great stimulus to our strength, invigorates our senses, and sometimes induces ferocity; as is evident from the Anthropophagi, carnivorous animals, wild beasts and their whelps, and hunters, particularly if the abuse of aromatics, wines, and medicines, has supervened. Vegetables, on the contrary, increase the lentor of the fibres, weaken the strength, diminish sensibility and irritability; in a word, induce a phlegmatic disposition; in which potatoes have a wonderful effect. It would be of great consequence to pay regard to this in the bringing up of children, viz. to invigorate the inertia of the mental and corporeal faculties by the use of animal food, but to temper the vehement passions, peculiar to choleric persons, by using amongst food a good deal of vegetables. (2.) The particular mode of education, examples. It need scarce be insisted on of what influence these are possessed, particularly in infancy: hence it happens, that whole nations are of one temperament. (3.) Climate, weather, native country. Rarely in an unsettled climate or country, in hot climates, or in moist countries, will you find in choleric persons that alacrity of temper, agility of body, and quickness of understanding, which is so common in a serene and temperate heaven, and high hilly countries. (4.) The increase of knowledge. I have often admired that change which a strenuous industry produces in some of the most dull men; so that

that with the increase of knowledge, they became of a more cheerful temperament. (5.) Abundance and want of necessaries, both in life and for the purpose of forwarding improvement. For this reason it may happen, that according to the diversity of the form of government, whether under mild or more severe and tyrannical laws, the temperament of the subject may be either lively or languid. (6.) The sort of life itself, intercourse with men, and public employment, may have a great share in changing temperaments; since rarely after the 36th year of a man's life do you find the blood still pure; and rarely a choleric person, who, after 50 years, has preserved his former alacrity. It is difficult to say into how many species temperaments should be divided, and what kind of character should be assigned to each, according to nature and not conjecture. I doubt, I may not be more successful than the celebrated Kaempfer and Gerresheimer, as I exhibit the first lines only. The sanguineous and phlegmatic temperaments, seem with various intermedia to comprehend all modifications. (1.) Then, the sanguineous, which is inconstant and not well specified, is distinguished by a vivid colour of the face; the vessels are full; and hence, for the most part, they take ill with external heat; they are predisposed greatly to inflammatory diseases; they have a great share of sensibility and irritability, which all therefore indicate a desire of pleasure in this temperament, and the greatest inquietude, both of body and mind, prevails: they are talkative; abide not long with any occupation; they are easily seduced, and contract an intimacy with every body; but they soon forget their friends, showing a certain diffidence to all of them; they seldom meddle with affairs of any consequence, and rarely acquire proficiency in the sciences, unless in an advanced age. (2.) The sanguineous-choleric enjoys a better mixture of causes; it has the supports of health and cheerfulness along with the former, but has perseverance

severance in common with the choleric. (3.) The choleric: Here you will always observe the body tender, though not emaciated and dry as is the case with the melancholic; the skin is of a whitish yellow, with red hairs; the balls of the eyes are of a moderate magnitude, the pupil being frequently dim; a penetrating lively countenance, sometimes joined with a degree of ferocity; a quick pulse; actions of the muscles in walking, speaking, and other respects very rapid; copious and acrid bile; hence an effectual peristaltic motion, more frequent stools, a ready inclination to undertake any thing of consequence, formed as if to command, and particularly fond of animal food. (5.) The hypochondriac: An unhappy temperament, troublesome to itself and others. Men of this sort, for the most part, are subject to diseases in the liver, have a yellowish appearance, always discontented, wonderfully tortured with envy and diffidence, and are called by some *choleric-melancholic*. (6.) The melancholic have a dejected aspect: The eyes, for the most part, small, retracted, and winking; the hair black, and skin rigid, remarkable for its dryness and leanness; a small and slow pulse, sparing and black bile, a slow peristaltic motion. They indeed have quick perceptions, and ponder long; they submit to toilsome labour with the greatest patience, but finish it with incredible slowness: for the most part they pay no regard to time. They easily bear the disadvantages of life; but when once their anger is excited, they love revenge. (7.) The *bræotic* or rustic joins a great share of the sanguineous temperament with the melancholic and phlegmatic. The body is lusty, full of juices, a small irritability in its strong muscles, and some stupor in its small nerves. Persons of this sort are capable of no education; and whatever they undertake favours of a low turn of mind. (8.) The gentle and mild temperament: this is composed of the sanguineous, choleric, and phlegmatic. They

They are a good race of men, wishing well to all : in them we always perceive a calmness and sweetness of manners ; they strongly hate a prating, noisy loquacity : if devoted to study, they calmly undertake the task, anxiously ponder what they learn, and are capable of great proficiency. (9.) The slow phlegmatic is distinguished by a soft and mostly whitish skin, a very lax body, very prominent eyes, drowsy aspect, a slow pulse and walk : for the most part they speak slow, are patient of the weather's inclemency and other peoples affronts ; born to obey ; and, on account of their slight irritability, difficultly enraged, and easily pacified again.

§ 8. *Of the Circulation or Motion of the Blood through the Arteries and Veins.*

THE arteries and veins contain either blood or lymph. The red blood fills the arteries and veins commonly known, which we call *red*, or those of the first order, and which have their origin in the heart. These it so fills in a living person, that at some times they are very loosely and imperfectly distended by it, and at other times they are rendered very full and turgid. After death, the veins are found fuller of blood than the arteries ; but sometimes, when the person has been dead a considerable time, the small veins have been found distended with air. But the arteries of a dead body commonly contain only a small quantity of blood.

This distending blood, then, is rapidly moved thro' all the vessels of a living body. The truth of which is demonstrated to us from wounds, by which the patient soon expires from the loss of so much blood as was necessary for the maintenance of life ; which loss of blood happens almost instantly from the larger arteries, and sometimes very suddenly from the smaller ones : but from the veins, unless they are some of the largest, this loss of blood is more slow and difficult ;
yet

yet are there not wanting instances of fatal hemorrhages from wounds of the veins, in the inner corners of the eyes, and those under the tongue. Experiments made upon living animals sufficiently evidence the impulse and rapidity with which the blood is moved, particularly through the arteries. The height to which blood from cut carotids ascended, according to Hales's calculation, Dr Wrisberg saw confirmed in robust men who had been sentenced to die, to wit, about seven feet; with this difference, however, that in two examples the blood sprung higher from the vertebrals than from the carotids. In the larger trunks, it runs most swiftly; but in the least of them, somewhat slower. And, in the larger veins, the blood's celerity is less than in the arterial trunks, in the same proportion as the lights or sections of the arteries are less than those of the veins, i. e. twice or almost thrice slower. Another argument of the circulation, is the compressure and relaxation of a vein, whereby the motion of the blood is promoted from one valve to another. This motion of the blood is, in the veins, uniform or equable enough; but in the arteries it is alternately greater when the vessel is more dilated, and less when it is contracted. This is proved by ocular inspection in living animals.

That the motion which the blood describes, is a course through the sanguineous arteries into the veins, is discovered from experience. For, first, it is certain, that all the arteries and veins communicate or open one into the other; because often, from one, and that a small artery, all the blood shall run even until death, and make all the flesh exceedingly pale; and this not only out of the wounded limb, but from the whole body. Of such fatal examples we have a number, from an inner artery of the nose, from the gums, a finger, tooth, cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the skin, and even the bite of a leech. There are, there-

therefore, of course, open ways, by which the blood speedily flows from the venous into the arterial system.

That the blood, again, in the arteries, flows from the heart toward the extreme parts of the body, is proved by the microscope, and by a ligature on the artery of a living animal, and likewise by the fabric, mechanism, and proportion of the semilunar valves between the arteries and their corresponding ventricles. Whatever artery is stopped by a ligature, the swelling ensues in that part betwixt the heart and the ligature, whilst the other part is emptied beyond the ligature, which is the part of the artery more remote from the heart: neither has it there any pulsation; nor if it be there wounded, will it yield any blood. The same effects, which we see follow from a ligature, are likewise often produced by disease; as when some tumor, by compressure, or an aneurism, intercepts the blood's motion from the heart. Experiments of this kind have been made on most of the arteries; anastomoses, however, or the blood flowing through a neighbouring branch, or the retrocession of the blood in a dying animal, form exceptions to this rule.

But of the course or motion of the venous blood, it has been always more doubted; almost all the ancients have been persuaded, that the blood in the veins flowed through them, either from the heart or from the liver, to all parts of the body. Very few of them have known that this was an error. Several of them have, indeed, acknowledged it to be false in the pulmonary vein. But that the blood did not move from the heart in the vena cava was known to still fewer anatomists of the ancients: only to Andreas Cæsalpinus by chance, and (from an extraordinary accident) to Vesalius.

Dr William Harvey was the first who experimentally asserted the motion of the blood returning in the veins to the heart, in such a manner as to render the whole intelligible, and leave no room to doubt of it. And, first, the valves of the veins lead us to this truth: for

the common use or office of these valves is, to determine the pressure that is given from any quarter upon the veins, towards the heart, by allowing no opportunity to the venous blood that has once entered the trunk, which they intercept, to flow back to the branches. For, since the covering spaces of the valves open upwards towards the heart, the blood enters and expands them. Thus those parts of the valves which project freely into the cavity of the vein, approach towards the axis, until the opposite sides by meeting together shut up the tube. This we know from inflations, ligatures, and injections of the veins; for you never can force a liquor easily into the veins by propelling it against their valves. They do not, indeed, every where shut up the whole cavity of the veins; but where they shut not close, they always intercept the greatest part of the light.

Another office of the valves in the veins seems to be for sustaining the weight of the blood, that its upper columns may not gravitate upon the lower; nor the blood, flowing through the trunks, make too great a resistance against that which follows it through the branches. For if, from the slower motion of the blood, its weight or pressure shall, in any part, much exceed the impulse that drives it on, so as to cause some part of the column to descend by its weight; it is, in that case, immediately caught, and sustained in its relapse by the next adjacent valve, which hinders it from urging against the next succeeding column, and affords time and opportunity for some contiguous muscle by its pressure or concussion to propel the said column. And this is the reason why valves are placed in the veins of the limbs and neck; in which parts they are both more numerous and more robust than elsewhere. And this is the cause of varices, when the blood, entering the hollow valves, urges their solid convexity downwards, and makes the vein dilate in that part. Likewise, in muscular action, the valves are the cause
of

of the whole effect of the pressure which the veins sustain, forwarding the blood in its due course towards the heart.

Moreover, the valves, placed in the right ventricle of the heart, have such a fabric that they freely permit blood, air, or wax to pass from the venous trunks of the cava into the heart, but deny any reflux from the heart into the veins.

Again, ligatures, in a living person, may make the thing more evident. When the veins of the limbs are tied, either by design or accident, with the limb itself about the hams, arms, ancles, or wrists, the limb below the ligature swells, the veins fill and distend themselves, and when opened make a free discharge of blood: but at the same time nothing of this kind happens above the ligature, nor are any of the veins to be seen there. The same phenomenon happens when the veins are compressed by swelled scirrhus glandules in the viscera; and from polypuses the veins are often greatly swelled or enlarged into tumors. These ligatures will serve to keep the blood in any limb round which they are tied, that it may not return to the heart, and be lost through a wound in another part.

The experiments to prove this course of the blood, which have been made in living animals, are still more accurate. From them, even from our own, it appears, that by tying any vein, in a living animal, near the cava, or belonging to the pulmonary veins, that part always swells which is most remote from the heart, all below the ligature appearing distended with the retained blood, while above and next the heart they are pale and flaccid. Lastly, if the arteries are tied at the same time with the veins, these last remain flaccid and empty; but, upon removing the ligature from the arteries, the veins are immediately filled.

In like manner, the infusion of poisons or medicinal liquors show, that, into whatever vein you inject chemical acid spirits, the blood is driven along with the
force

force of the poison to the heart itself. But when, from this cause, the brain is affected with the narcotic virtue of opium, and the intestines and stomach with the virtue of purgatives and emetics; this is a demonstration that the blood, with which these substances were mixed, had passed through the ramifications of the veins to the heart, and from thence through the whole body.

Another proof we have in the *transfusions* of blood; in which all the blood from the arteries of one animal is urged into the veins of another exhausted of blood; whereby the heart, arteries, and empty veins of the latter become so turgid and well replenished, that they work the whole machine of the animal with a remarkable degree of vivacity, or even cause it to labour under a plethora.

But that the blood passes from the least arteries into the least veins, we are clearly taught by *anatomical injection*; where, by one arterial trunk, we easily fill all the arteries and veins, almost throughout the whole body; provided the liquor be watery or very fluid, so as to pass easily in the vessels of the head, mesentery, heart, and lungs.

Lastly, *the microscope* has put the matter beyond all doubt in the pellucid tails, feet, and mesenteries, of animals; where we see that the blood, brought to the extreme parts by the arteries, is poured either into small veins continuous with the reflexed artery, or else goes through branches of the arterial trunk into the parallel communicating vein, by which it goes on to the parts nearest the heart. This is the way in which the blood passes as well into the least veins which are capable of receiving only one globule, as into those that are somewhat larger, being able to admit two or more globules to advance forward in a breast. But that there is no spongy or parenchymous interposition betwixt the arteries and veins, in the general course of the circulation, is proved both from microscopes and injections. For if there were any such parenchyma or

spongy mass betwixt the arteries and veins, the hardening injections would show it, by appearing extravasated in a like unshapen mass.

The circulation of the blood is, therefore, now received by every one as a medical truth; namely, that all the blood of the human body is carried through the aorta, from the left cavity of the heart, to the extreme parts or converging ends of the arterial branches; from whence the whole mass is again transmitted into the least veins, which convey it to the larger, and from them into the cava and heart itself; in which course it perpetually goes and returns during life.

Yet there are some instances where, by passions of the mind, a sudden revulsion by copious blood-letting, or convulsions, the blood has been forced to recede back from the smaller into the larger arteries; and, on the other side, where an obstruction being formed above the valves, the blood has been known to slide back from the venous trunks into their smaller branches. But then these accidents are very momentaneous or sudden, and the blood soon returns into its natural course. These things happen most frequently in the abdomen and vena portarum.

The course of the humours *in the lymphatic veins* which have valves, appears both from the nature of those veins and from ligatures: for every lymphatic vein tied swells betwixt the smaller extremities of it and the thoracic duct; but grows flaccid betwixt the said duct and the ligature. All the valves in these, like those of the blood-veins, give a free passage for flatus and mercury to flow to the thoracic duct: but they make a resistance, and often an obstinate one, to any return the other way; although sometimes they have been known to yield.

The vapours that moisten the whole cellular substance, the steams of the abdomen and other venters, are all thus drunk up by the least pellucid veins, and so conveyed to the blood-veins, that their contained juices may

may pass on to the heart: and from thence it is, that œdema ensues, when a vein is compressed by a ligature; because by intercepting the course of the absorbing veins by the ligature, the vapours stagnate unabsorbed. In the other smaller vessels, we can make no experiments: but they appear conformable to what we have said, both from reason and analogy; and are likewise supported by the experiments of water or other liquors, absorbed out of the cavity of the intestines, thorax, and pulmonary vesicles.

All juices, therefore, in the human body, are drove out of the heart into the aorta; from whence they are all returned again to the heart by the least veins; those humours only excepted, which are exhaled or discharged withoutside the cavities of the body. To complete this circle, it only remains for us to find out a course for the blood, from the right to the left cavities of the heart: but then this supposes us to be first acquainted with the history of the heart and the pulmonary vessels.

§ 9. Lungs.

Situation in general and figure. The lungs are two large spongy bodies, of a reddish colour in children, greyish in adult subjects, and bluish in old age; filling the whole cavity of the thorax, one being seated in the right side, the other in the left, parted by the mediastinum and heart; and of a figure answering to that of the cavity which contains them, that is, convex next the ribs, concave next the diaphragm, and irregularly flatted and depressed next the mediastinum and heart.

When the lungs are viewed out of the thorax, they represent in some measure an ox's foot, with the fore-part turned to the back, the back-part to the sternum, and the lower part to the diaphragm.

Division and figure in particular. They are distinguished

guished into the right and left lung ; and each of these into two or three portions called *lobi*, of which the right lung has commonly three, or two and a half, and the left lung two. The right lung is generally larger than the left, answerably to that cavity of the breast, and to the obliquity of the mediastinum.

At the lower edge of the left lung, there is an indented notch or sinus opposite to the apex of the heart, which is therefore never covered by that lung even in the strongest inspirations, and consequently the apex of the heart and pericardium may always strike against the ribs; the lungs not surrounding the heart in the manner commonly taught. This sinus is expressed in Eustachius's tables.

Structure. The substance of the lungs is almost all spongy, being made up of an infinite number of membranous cells, and of different sorts of vessels spread among the cells, in innumerable ramifications.

Coats. This whole mass is covered by a membrane continued from each pleura, which is commonly said to be double; but what is looked upon as the inner membrane, is only an expansion and continuation of a cellular substance, which shall be spoken to after I have described the vessels of this viscus.

Bronchia. The vessels which compose part of the substance of the lungs are of three or four kinds; the air-vessels, blood-vessels, and lymphatics, to which we may add the nerves. The air-vessels make the chief part, and are termed *bronchia*.

These bronchia are conical tubes, composed of an infinite number of cartilaginous fragments, like so many irregular arches of circles, connected together by a ligamentary elastic membrane, and disposed in such a manner as that the lower easily insinuate themselves within those above them.

They are lined on the inside by a very fine membrane, which continually discharges a mucilaginous fluid; and in the substance of the membrane are a
great

great number of small blood-vessels, and on its convex side many longitudinal lines, which appear to be partly fleshy, and partly made up of an elastic substance of another kind.

The bronchia are divided in all directions into an infinite number of ramifications, which diminish gradually in size; and as they become capillary, change their cartilaginous structure into that of a membrane. Besides these very small extremities of this numerous series of ramifications, we find that all the subordinate trunks, from the greatest to the smallest, send out from all sides a vast number of short capillary tubes of the same kind.

Vesiculæ bronchiales. Each of these numerous bronchial tubes is widened at the extremity, and thereby formed into a small membranous cell commonly called *a vesicle*. These cells or folliculi are closely connected together in bundles; each small branch producing a bundle proportionable to its extent and the number of its ramifications.

Lobuli. These small vesicular or cellulous bundles are termed *lobules*; and as the great branches are divided into small rami, so the great lobules are divided into several small ones. The cells or vesicles of each lobule have a free communication with each other, but the several lobules do not communicate so readily.

Interlobular substance. The lobules appear distinctly to be parted by another cellulous substance, which surrounds each of them in proportion to their extent, and fills up the interstices between them. This substance forms likewise a kind of irregular membranous cells, which are thinner, looser, and broader, than the bronchial vesicles.

This substance is dispersed through every part of the lungs, forms cellulous or spongy *vaginæ*, which surround the ramifications of the bronchia and blood-vessels, and is afterwards spread over the outer surface of each lung, where it forms a kind of fine

cellular coat, joined to the general covering of that viscus.

When we blow into this interlobular substance, the air compresses and flattens the lobuli; and when we blow into the bronchial vesicles, they presently swell; and if we continue to blow with force, the air passes insensibly into the interlobular substance. We owe this observation to M. Helvetius.

Vascular texture. All the bronchial cells are surrounded by a very fine reticular texture of the small extremities of arteries and veins which communicate every way with each other. The greatest part of this admirable structure is the discovery of the illustrious Malpighi.

Blood-vessels. The blood-vessels of the lungs are of two kinds; one common, called *the pulmonary artery and veins*; the other proper, called *the bronchial arteries and veins*.

The pulmonary artery goes out from the right ventricle of the heart: and its trunk having run directly upward as high as the curvature of the aorta, is divided into two lateral branches; one going to the right hand, called *the right pulmonary artery*; the other to the left, termed *the left pulmonary artery*. The right artery passes under the curvature of the aorta, and is consequently longer than the left. They both run to the lungs, and are dispersed through their whole substance by ramifications nearly like those of the bronchia, and lying in the same directions.

The pulmonary veins having been distributed thro' the lungs in the same manner, go out on each side, by two great branches which open laterally into the reservoir or muscular bag of the right auricle.

The ramifications of these two kinds of vessels in the lungs, are surrounded every where by the cellular substance already mentioned, which likewise gives them a kind of vagina; and the rete mirabile of Malpighi, described above, is formed by the capillary extremities

ties of these vessels. It must be observed, that the ramifications of the arteries are more numerous and larger than those of the veins, which in all other parts of the body exceed the arteries both in number and size.

Bronchial arteries and veins. Besides these capital blood-vessels, there are others called the *bronchial arteries and veins*, which are very small, but they follow the bronchia through all their ramifications. They communicate with the pulmonary arteries and veins in many places; likewise with the arteries and veins of the œsophagus, and with branches of the coronary artery and vein.

The varieties in the origins of the bronchial arteries and veins, especially of the arteries, their communications or anastomoses with each other and with the neighbouring vessels, and above all, the immediate anastomosis of the bronchial artery with the common pulmonary vein, are of so great consequence in the practice of physic, that it will be proper to repeat here what we have said about them elsewhere, that the attention of the readers may not be diverted by being obliged to turn to another place of this work.

The bronchial arteries come sometimes from the anterior part of the aorta descendens superior, sometimes from the first intercostal artery, and sometimes from one of the œsophagææ. They go out sometimes separately, toward each lung; sometimes by a small common trunk, which afterwards divides to the right and left, near the bifurcation of the aspera arteria hereafter to be described, and follow ramifications of the bronchia.

The left bronchial artery comes pretty frequently from the aorta; and the right, from the superior intercostal on the same side, because of the situation of the aorta. There is likewise another which arises from the aorta posteriorly near the superior intercostal, and above the anterior bronchialis.

The bronchial artery gives off a small branch to the

auricle of the heart on the same side, which communicates immediately with the coronary artery.

Sometimes one bronchial artery gives origin to several superior intercostals; and sometimes several bronchial arteries send off separately the same number of intercostals.

The bronchial veins, as well as arteries, were known to Galen. The vein on the left side goes into the left superior intercostal vein, while the trunk on the right side passes into the vena azygos; and sometimes both veins are branches of the gutturalis.

Nerves. The lungs have a great many nerves distributed through them by filaments which accompany the ramifications of the bronchia and blood-vessels, and are spread on the cells, coats, and all the membranous parts of the lungs. The eight pair and great sympathetic nerves, form behind each lung a particular intertexture, called *plexus pulmonaris*; from whence nervous filaments go out, which communicate with the plexus cardiacus and stomachicus.

Lymphatic vessels. On the surface of the human lungs, between the external and cellular coat, we observe lymphatic vessels: but we ought to take care not to mistake for such vessels a transparent reticular substance observable on the surface of the lungs after blowing strongly into the lobuli; this appearance being entirely owing to the air which passes through the bronchial vesicles into the interlobular cells, and which, by separating a certain number of lobuli, finds room to lodge between them.

Ligaments. Under the root of each lung, that is, under that part formed by the subordinate trunk of the pulmonary artery, by the trunks of the pulmonary veins, and by the trunk of the bronchia, there is a pretty broad membranous ligament which ties the posterior edge of each lung to the lateral parts of the vertebræ of the back, from that root all the way to the diaphragm.

Tra-

Trachea arteria. The bronchia already described, are branches or ramifications of a large canal, partly cartilaginous, and partly membranous, called *trachea* or *aspera arteria*. It is situated anteriorly in the lower part of the neck, from whence it runs down into the thorax between the two pleuræ, through the upper space left between the duplicature of the mediastinum, behind the thymus.

Having reached as low as the curvature of the aorta, it divides into two lateral parts, one toward the right hand, the other toward the left, which enter the lungs, and are distributed through them in the manner already said. These two branches are called *bronchia*; and that on the right side is shorter than that of the left, whereas the right pulmonary artery is the longest.

The trachea is made up of segments of circles of cartilaginous hoops, disposed in such a manner as to form a canal open on the back-part, the cartilages not going quite round; but this opening is filled by a soft glandular membrane, which completes the circumference of the canal; but this cannot be to give way to the œsophagus; for, instead of descending immediately upon the middle of that canal, the trachea inclines a little to the right side, and the same structure is found in the back-part of the great bronchial vessels, which are at some distance from the œsophagus.

Each circle is about the twelfth part of an inch in breadth, and about a quarter of that space in thickness. Their extremities are round; and they are situated horizontally above each other, small interstices being left between them, and the lower edge of the superior segments being turned toward the upper edge of those next below them.

They are all connected by a very strong elastic membranous ligament fixed to their edges. I have observed the first three segments united into one bent alternately in two different places according to its breadth. Sometimes two are continuous in the same manner.

The

The trachea is covered externally with a quantity of cellular substance, which unites it to the neighbouring parts, and it is lined on the inside by a particular membrane; which appears to be partly fleshy or muscular, and partly ligamentary, performed by an infinite number of small holes more or less imperceptible, through which a mucilaginous fluid continually passes, to defend the inner surface of the trachea against the acrimony of the air which we breathe.

This fluid comes from small glandular bodies dispersed through the substance of the membrane, but especially from glands something larger than the former, which lie on the outer or posterior surface of that strong membrane by which the circumference of the canal is completed. The same structure is observable in the ramifications of the trachea from the greatest to the smallest.

All the vessels of which the lungs are chiefly composed, that is, the air-vessels or bronchia, and the blood-vessels, or the pulmonary and bronchial arteries and veins, accompany each other through this whole viscus.

They are disposed commonly in such a manner, even to the last ramifications, as that a subordinate trunk or branch of the bronchia lies between the like trunks or branches of the pulmonary artery and vein; the bronchial vessels being immediately joined to the bronchia. In some places these three kinds of vessels touch each other in such a manner as to leave a triangular space in the middle.

The bronchia are divided into a very great number of ramifications; and the last rami are the pedicles or footstalks of the small lobuli. All the lobuli are angular, oblong, broad, thin, &c. The footstalks send out other smaller membranous pedicles, which are very short, and terminate in the bronchial vesicles or cells, of which they are continuations. The subordinate

trunks and rami detach a great number of these pedicles from their convex surface.

When we blow into the lungs, the bronchial cells nearest their outer surface appear like small portions of round vesicles; and from this appearance all the bronchial cells have got the name of *vesicles*, though they are all angular except those which I have now mentioned.

When we examine a lung without blowing it up, we find that the cartilaginous segments of the bronchia lie so near as to be engaged in each other; and in drawing out any portion of the bronchia by the two ends, these segments are parted; and the whole canal is increased in length; but it contracts again, by means of its elastic membrane, as soon as that force is taken off.

When we open lengthwise any portion of the pulmonary artery and vein in the same lung, we meet with a great number of transverse rugæ, which are destroyed when these vessels are elongated. This is an observation made by M. Helvetius.

By virtue of this structure, all the ramifications both of the bronchia and pulmonary arteries and veins, have constantly the same direction, whether the lung be inflated or collapsed; and they contract in length, without being either contorted or folded. In expiration these vessels are elongated, and shortened in inspiration.

These three vessels lie in a sort of cellular vagina, which accompanies all their ramifications; and is [a continuation of their interlobular cells, or cellular substance, in the interstices of the lobuli. The pelliculæ which compose it, are, however, there disposed in a more regular manner, and more longitudinally, than in other places, and thereby appear to form a true vagina.

When we blow through a pipe introduced so far as to touch immediately a trunk of the blood-vessels or bron-

bronchia, the air runs at first through all the cells that lie nearest that trunk or its branches; but if we continue to blow, it insinuates itself through the whole interlobular substance.

Bronchial glands. At the angle of the first ramification of the trachea arteria, we find on both the fore and back sides certain soft, roundish, glandular bodies, of a bluish or blackish colour, but reddish in a child; in size they vary from that of a field-bean to that of a millet-seed. Through these the lymphatic vessels of the lungs pass in their way to the thoracic duct.

The trachea has several coats, as has been already observed. The outermost or common covering surrounds that part of the trachea which lies in the thorax; but out of the thorax, this first coat is derived from the aponeurotic expansions of the muscles of the neck; and it is between this and the following covering that the glands already mentioned are situated.

The second is a proper coat, being a continuation of the cellular covering of the lungs; the pelliculæ of which, nearest the cartilaginous segments, serve them for an external perichondrium. The third membrane lies on the inside, adhering closely to the same cartilages, and supplying to these the place of an internal perichondrium.

The fourth membrane is that which completes the circumference of the cartilaginous circles of the trachea. It consists chiefly of two laminæ or strata, partly muscular and partly tendinous; the external or posterior lamina being made up of longitudinal fibres; and the internal, or anterior, of transverse fibres. This membrane is perforated by the small ducts of the above-mentioned glands, which discharge a fluid when pressed; and being examined through a microscope, they appear vesicular or folliculous, much like that of the stomach.

The ligaments between the cartilaginous circles are very strong and elastic; and each of them is confined to

to two cartilages, without communicating with any of the rest; being fixed to the edges of these cartilages, much in the same manner as the intercostal muscles are inserted in the ribs.

As the bronchia penetrate into the substance of the lungs, they gradually lose their cartilages, till at last they become purely membranous; but the muscular lines of M. Morgagni appear as much, and sometimes more than before. The two planes above-mentioned continue likewise to be visible; and we observe very distinctly, sometimes even without a microscope, a great many small holes in the pellicles of the lobuli, and bronchial vesicles or cells which open from within outwards.

Uses. Respiration is performed by organs of two kinds; one of which may be looked upon as active, the other as passive. The lungs are of the second kind, and the first comprehends chiefly the diaphragm and intercostal muscles.

As soon as the intercostal muscles begin to contract, the arches of the ribs are raised together with the sternum, and placed at a greater distance from each other; by which means the cavity of the thorax is enlarged on the two lateral and anterior sides.

At the same instant the diaphragm is flatted or brought toward a plane by two motions, which are apparently contrary; that is, by the contraction of the diaphragm, and the dilatation of the ribs in which it is inserted. The external surface of the thorax being thus in a manner increased, and the cavity of the bronchia being at the same time, and by the same means, less resisted or pressed upon, the ambient air yields to the external pressure, and insinuates itself into all the places where the pressure is diminished; that is, into the aspera arteria, and into all the ramifications of the bronchia, all the way to the vesicles. This is what is called *inspiration*.

This motion of inspiration is instantaneous, and ceases

ses in a moment by the relaxation of the intercostal muscles; the elastic ligaments and cartilages of the ribs bringing them back at the same time to their former situation. This motion by which the ribs are depressed and brought nearer to each other, is termed *expiration*.

The pulmonary arteries and veins which accompany the bronchia through all their ramifications, and surround the vesicles, transmit the blood through their narrow capillary extremities, and thereby change or modify it, at least in three different manners.

The first change or modification which the blood undergoes in the lungs, is to have the cohesions of its parts broken, to be attenuated, pounded, and, as it were, reduced to powder. The second is, to be deprived of a certain quantity of serum, which transpires through the lungs, and is what we commonly call the *breath*. The third is, to be in a manner reanimated by the impression of the air, whether the whole body of the air enters the blood, whether the common air is only the vehicle of some finer parts which are conveyed to it, or whether the air only compresses and shakes the blood as it passes round the bronchial vesicles in the reticular capillary extremities of the vessels.

The cartilages of the aspera arteria and bronchia serve in general to compose a canal, the sides of which will not sink in or subside by compression, but will nevertheless yield to certain pressures and impulses without breaking. As these cartilages are not complete circles or rings, and as their circumferences are completed by elastic membranes, they allow of those dilations and contractions which modulate the voice; and as they are connected by elastic ligaments of a considerable breadth, the alternate elongation and contraction of the bronchia is facilitated in the motions of respiration.

The larynx is commonly looked upon as the upper part of the aspera arteria: but we have already described

scribed it in the preceding chapter *of the Head*, with which it has a particular connection in relation to the tongue.

§ 10. *Respiration.*

THE lungs completely fill the sacs formed by the pleura. They are freely suspended by the great blood-vessels; unless you call that a ligament, which is made by the external membrane of the pleura going to the lungs and to the basis of the diaphragm. Betwixt the lungs and pleura is found a watery or rather serous vapour, of a coagulable nature, like that of the pericardium; which vapour transudes from the surface of the lungs continually in the foetus, and not unfrequently in the adult. This is sometimes increased, so as to form a dropsy; or thickens into a kind of sebaceous matter; or, lastly, concreting into fibres, joins the lungs to the pleura.

The vesicles of the lungs do not receive the air by a single orifice from the windpipe, as a vial; but the air, exhaling from the least branches of the said wind-artery, is admitted in such a manner into their irregular spaces, that it freely spreads through them from any one part of the lungs into all the rest, and returns again in like manner. This is demonstrated by inflation, which drives the air even through the least branches of the windpipe into the smallest lobes; from whence it readily passes into all the rest. Nor, in man and smaller animals, says Haller, is the cellular fabric of the intervals shut up from the vesicles of the lungs; but, according to Sabatier and other late writers, there is no communication between the common cellular substance and the cells of the lungs.

The air is driven into these vesicles through the windpipe, which arises from the larynx; and, in the upper part of the thorax is received between the laminae of the posterior part of the mediastinum.

Its

Its last branches are invisible, which exhale the air into the cellular spaces of adult lungs, and likewise receive the watery vapours exhaling from the arteries into the said spaces ; from whence they are thrown by expiration.

The blood-vessels of the bronchia are the arteriæ and venæ bronchiales ; but there are other larger vessels belonging to the lungs, called the *pulmonary artery* and *vein*. The great artery, in the foetus larger than the aorta, and in the adult but little less, has two branches ; the right larger but short, the left narrower and longer. In the foetus, the trunk itself is continued into the descending aorta, and is known by the name of *ductus arteriosus*. In an adult, that trunk degenerates into a solid ligament. The four pulmonary veins accompany the arterial branches and the aspera arteria of the windpipe in their course through the lungs, surrounded with a good deal of cellular substance ; which substance, being increased, at last composes the lungs themselves. Within this cellular fabric, and likewise upon the ultimate spaces or cells, the air-vessels and blood-vessels are subdivided, spread, and interwoven like a net ; and here the small arteries exhale a plentiful vapour into their cells, and the lymphatics absorb a watery vapour from the same cells. Hence water tinctured, the whey of milk, or a thin waxen injection, being urged into the pulmonary artery, flows with a froth into the windpipe ; or, on the contrary, being urged from the windpipe into the lungs, they penetrate into the pulmonary artery ; or from thence, lastly, a liquor injected by the arteries, readily enters the pulmonary veins ; and the reverse.

The lymphatic vessels, as in other parts, form a network upon the surface of the lungs, from whence there are branches conveying the lymph to the cavity at the back part of the mediastinum, and to the small glands which lie behind the œsophagus, opening at last into the thoracic duct. The anterior pulmonary nerves

are small, but the posterior ones somewhat larger: they come from a nerve of the eighth pair; and there are also some small nerves to the lungs from the recurrent, and likewise from the cardiac plexus, which enter together with the large blood-vessels. Hence, says Haller, the lungs have but little sensation; nor are they of an irritable nature. But Wrisberg remarks, contrary to this, that if he were to consider the number and magnitude of the bronchial nerves, he would be inclined to suppose, that the lungs of all the human viscera, the organs of sense excepted, receive, upon comparison, many nerves, and therefore possess sensibility.

The quantity of blood which enters into the lungs is exceedingly great, equal to (or even perhaps greater than) that which is sent in the same time throughout the rest of the body; which, therefore, demonstrates some very considerable use proper to this viscus. And that this use depends manifestly upon the air, appears from the universal consent of nature, in which we scarce find any animal without breathing; also from the structure of the lungs in the foetus, in which, for want of air, they are useless, receiving only a small portion of the blood, which the pulmonary artery conducts from the heart. We come next, therefore, to speak of respiration, by which the air is drawn into and expelled from the lungs.

The element of air appears, from the principles of philosophy, to be an elastic and sonorous fluid, with a spring which cannot be destroyed. But the atmospheric air, which we commonly receive into the lungs, is impure, filled with a great quantity of watery and other vapours, also with salts and the universal acid, with the seeds of plants and animals, and other foreign matters; but in very minute particles, having a specific gravity 859 times less than water, a cubic foot of air weighing between 610 and 694 grains. This air, which surrounds the earth on all sides, being pressed

by the incumbent columns of its own mass, perpendicularly, laterally, and in all directions, enters wherever it meets a less resistance, and with a considerable force, as appears from experiments made with empty or exhausted vessels, and by the air-pump; so that its pressure on the human body is not less than 3000 pounds weight. It is repelled chiefly by the pores of the membranes, which yet are permeable by water: it likewise penetrates oil or mucus with difficulty.

This air is excluded from all parts of the human body by the surrounding close skin, which, even when dried or tanned, is impervious to the air; but more so, as under the skin is placed the fat, making an equal resistance to the narrow openings of the absorbing vessels. It, therefore, now remains for us to inquire, why the air enters the lungs of an adult person; for with this they are in a manner constantly full, and of course are equally pressed, and resisting against the weight of the whole atmosphere: but that the lungs always contain air is evident; because, however close you compress them, they will be still lighter than water; and even in the foetus, after they have been inflated but a few times, they always swim; whereas they sink to the bottom of water, if they have not given admittance to the air.

The equilibrium of the air's pressure being removed in any place, it constantly descends or flows that way where it is least resisted. But air that is dense and heavy will descend more easily than such as is light, whose force scarce overcomes that of the air which is already in the lungs, nor is able by the same force to overcome the resistance of the bronchia, and force by which the lungs compress the air contained in them. Hence an animal lives better in a dense than in a light air: although that kind of air is always most tolerable, which is pure at the same time that it is light; such as that of the highest mountains of the Alps. Therefore, for the air to enter the lungs, they must make a
less

less resistance to it than before ; namely, the air, which is already in the cellular fabric of the lungs, must be rarefied : but this effect will follow, if the cavity of the thorax, in which the lungs are contained, and which they exactly fill, be dilated. Thus the air, which is always in the lungs, expands into a larger space ; by which, being weakened in its spring, it makes a less resistance to the external air ; and consequently a portion of the said external air descends into the lungs, sufficient to restore the confined and rarefied air, filling the lungs to the same density with that of the external air.

In order to dilate the seat of the lungs, and thus to put the body in such a state that the external air may rush into the lungs, it is necessary for the thorax to be elevated. By this means all the sections of the thorax form right angles, and its capacity is increased. This motion is performed by various muscles, which either operate constantly or only at certain times. The intercostal muscles, therefore, all of them act perpetually in elevating the ribs : but some doubt has arisen about the action of the internal intercostals ; because their lower part is inserted into that portion of the rib which is nearest its articulation with the vertebræ, and which therefore seems to be the least moveable : however, they elevate the ribs notwithstanding this ; for the great firmness or immobility of the upper rib, exceeding that of the lower, is evident from the articulation, weight, and ligaments there formed, which surpasses that mobility, arising from the greater distance of the centre of motion. This appears from the dissection of living animals ; in which we see the inner intercostal muscles operate in the elevation of the ribs, and rest in the depression of them also from a flexible thread fixed to the rib of some human skeleton, and drawn in the same direction with that of the fibres of the inner intercostal muscles ; by which means the lower rib will be always approximated towards the upper.

The greater firmness also of the upper ribs proves this, as they serve for a fixed point to the lower ones : for the first or uppermost ribs are from eight to twelve times firmer and less moveable than the lower true ribs ; but the difference of distance in them from the centre of motion, is scarcely the twentieth part of the length of their whole lever. Lastly, the elevating power of the internal intercostal muscles appears plainly by experiment in a dead subject ; when, by the thorax being raised, the muscles instantly swell.

By the action, therefore, of these muscles, the thorax is elevated, not altogether as one machine, nor would respiration be assisted by such a motion ; but the ribs turning upon their articulations, though behind they are but little moved, yet the fore-part of their extremities descends, and forms larger angles both with the sternum and vertebræ ; but from thence in the middle of their arches, by ascending, their lower edges are drawn upward. At the same time, the sternum is thrust out forward more from the vertebræ and from the ribs. Thus the ribs are both removed farther from the vertebræ, and the right ribs depart from the left ; and the diameter on both sides, betwixt the right and left ribs, betwixt the sternum and the vertebræ, is increased almost to two lines : and therefore this enlargement, following in every imaginable section of the thorax, will sufficiently dilate the cavity of the breast. This action of the ribs is more particularly complete in women, and in men who have no shortness of breath. These effects are produced least of all by the first ribs, but more by the following ones. In very strong inspiration, the ribs descend both behind and before ; and, along with these, the sternum and the spaces between the cartilage are lessened. But this dilatation alone is not sufficient for healthy breathing : nor is it so conspicuous or evident in men ; although, in them, the intercostal muscles, by retaining and elevating the ribs, very much assist the inspiration in a tacit manner, while

while they afford a fixed point to the diaphragm, that the whole force of that muscle may be spent, not so much in depressing the ribs, as in urging down the abdomen. The greater part, therefore, of the space which the thorax gains in inspiration, arises from the action of the diaphragm; the centre of which is more moveable and at liberty than the rest; except in the middle of its tendinous part near the fleshy margin, where the incumbent heart makes a resistance; but the lateral parts and the fleshy portions belonging to them are the most moveable.

There are two holes in the diaphragm; of which that on the right side of its tendinous part is somewhat square, and circumscribed by four strong tendinous portions; the left, which is elliptical, lies betwixt the right and left fleshy portions, which arise from the middle of the bodies of the vertebræ of the loins: under this opening they decussate and cross each other once or twice, but above they end in the tendon. This left opening is therefore drawn close together in the contraction of the diaphragm, while it is probable that the other opening remains immovable. The tendons are but little changed in the motion of the muscles.

The structure of the parts, and the dissection of living animals, demonstrate, that the fleshy portions of the diaphragm, which on all sides ascend from the firm parts to the middle and more moveable, do, by their contraction, depress the same, and by that means draw downward the lateral bags of the thorax, which contain the lungs; and, by this means, the perpendicular diameter of the thorax is considerably increased. The fleshy parts are more depressed; the tendon less; both because it is fixed to the pericardium, and because its own substance does not contract. Even the œsophagus and vena cava are contracted, while the diaphragm exerts its action. So that the diaphragm almost alone performs the office of respiration in a healthy man who is at rest; as also in that thorax whose ribs are fractu-

red, or the sternum burst, or where the person will not make use of his ribs by reason of pain. The force of the diaphragm also, in dilating the breast, is greater, according to the calculations that have been made, than all the rest of the powers which contribute to respiration. A strong inspiration is as yet confined; because, during the greatest exertion of the diaphragm, the lowermost ribs are brought inwards, and thus far the thorax is straitened. Lest this should always happen, the intercostal muscles interfere in ordinary inspirations; in very great ones they are inferior to the diaphragm. The phrenic nerve, which is more easily irritated than in most other muscles, forces the diaphragm to perform its office. The lungs themselves are altogether passive or obedient to the action of the air, ribs, and diaphragm; to which they are pressed into close contact on all sides, as through a large wound; and when the thorax is denudated by the knife, leaving its capacity entire, the lungs appear through the pellucid pleura and diaphragm.

But in larger inspirations, which receive a greater quantity of blood driven into the lungs, and when there is any obstacle or difficulty opposed to the action of the lungs themselves; in those cases, several other powers conspire to elevate the thorax: which powers are inserted either into the thorax, clavicles, or scapulæ; such as the scaleni muscles, trapezii, cervicales descendentes, serrati superiores, and pectorales; together with the small elevators; of which a more ample description may be had from professed systems of anatomy.

We have now surveyed the powers which are able to increase the capacity of the thorax in all its three dimensions. By these the cavity of the breast is dilated, so that it compresses the lungs less than before: the lungs then strive to diffuse themselves over that space, seeing they are never destitute of air, which expands itself by its elasticity as soon as the pressure is taken off. Without that muscular force the lungs have no proper
power

power of their own by which they are capable of attracting air: and even when they are most full of air, by having the *aspera arteria* closed, the animal vehemently attempts to inspire, by the efforts of its intercostal muscles and diaphragm. It therefore remains, that the air, which is a heavy fluid, and pressed on all sides by the incumbent columns of the atmosphere, must now enter the thorax with the greater force the less air the lungs contain; or yet more powerfully, if they contain no air: but with no force at all, if the air admitted through a wound in the breast presses upon the surface of the lungs. In this action, therefore, which is called inspiration, the bronchia are every way increased, both in length and diameter; because all the diameters of the thorax are increased: but in this act, the inflated lungs always follow closely contiguous to the pleura without leaving any intermediate space. At the same time, the pulmonary blood-vessels, which are wrapped up, together with the bronchia, in a covering of the cellular substance, are likewise with them extended in length, and spread out from smaller into larger angles; by which means, the circulation through them is rendered easier. While this is performing, the vesicular substance, or flesh of the lungs themselves, filled with air, increases those spaces through which the capillary blood-vessels of the lungs advance; whereby the vesicular pressure, upon each other, and upon those vessels adjacent, is lessened: thus, therefore, the blood will flow with greater ease and celerity into and through the larger and smaller vessels of the lungs. Hence a dying animal is revived by inflating its lungs, and facilitating the passage of the blood to the left ventricle of the heart; and thus people, seemingly dead by being kept a long time under water, are again recovered. But as for the pressure of the air upon the blood in the lungs in this action, it is so inconsiderable as not to deserve our notice, as being 300 times less than the force of the heart; nor can it ever urge the air into the blood, as it may be easily forced by art with a syringe.

It is by some questioned, Whether there be not air betwixt the lungs and the thorax? and whether this air, being rarefied in inspiration, is not afterwards condensed, so as to compress the lungs, and cause expiration? And they again ask, Whether this opinion be not confirmed by the instances of birds, in which we find this matter to be truly so? For by Camper's very elegant discovery, it is certain, that air passes into almost all the long bones of birds flying much in the higher regions, into the cavity of the sternum, the vertebræ, cranium, inferior maxilla, both from the lungs and through the Eustachian tube, and goes from one cavity into another: so it does not seem improbable, that the same may pass out by the surface of the body. But in birds, who soar not so high, the air gains admission through fewer bones. It is a pretty and sufficiently agreeable experiment, to perforate the humerus or femur; and the air inflated into the *aspera arteria* comes out at that foramen with the blood, which it has changed into froth; and *vice versa*, the air inflated through the hole distends the lungs. In like manner Wrisberg has seen mercury injected into a foramen of this kind make its appearance in the lungs. But we see every thing concurs to confute these opinions with respect to man and quadrupeds, &c.; for, immediately behind the pleura, in living quadrupeds, as well as in dead human bodies, the lungs are visible, without any intermediate space betwixt them; but the pleura being perforated, the lungs are immediately, by the contiguous air that enters, pressed together towards the vertebræ. In birds, indeed, the lungs, being pervious to the air, admit it into the cavity of the thorax through large holes in their substance. But in these there is a manifest space betwixt the lungs and the pleura. Large wounds, admitting the air only into one cavity of the thorax, diminish the respiration; but such wounds as let the air into both cavities, quite suffocate or suppress the respiration. The thorax being opened under
water,

water, sends out no bubbles of air through the said water; but in birds it does, because they have air in their thorax. The imaginable space betwixt the lungs and the thorax is always filled up by a watery or serous vapour, or else by the same vapour condensed into a watery lymph. If the lungs adhere, they injure the respiration but in a small degree; which ought entirely to cease, if it required an intermediate air betwixt the lungs and thorax. Finally, the external being admitted to any of the internal membranes of the human body, destroys their texture, if they are not defended by a plentiful mucus; of which we can find none upon the surface of the pleura.

But respiration, whether by the admixture of a sub-putrid vapour, or by some other method, certainly vitiates the air, and renders it unfit either for inflating the lungs or supporting flame; and lastly, it deprives that element of its elasticity. We may suppose that this happens from putrefaction, seeing the air is rendered pestilential by a crowd, and fevers of the most malignant kind are thus generated in a few hours. But in whatever manner this is produced, we are certain that the air is vitiated in the lungs; loses its elasticity; and thus cannot keep the lungs distended, so as to transmit an increased quantity of blood through the dilated pulmonary arteries into the veins. Nor can the will dilate the breast beyond certain bounds, or assist that passage of the blood in an unlimited manner. A state of body therefore will take place, in which the blood cannot pass through the lungs.

Thus is generated a new resistance to the blood continually coming from the heart: and in long retentions of the breath, as in making violent efforts, the venous blood, especially of the head, stagnates before the right ventricle of the heart being shut, because it cannot evacuate itself into the lungs; and thus swells up the face with redness, sometimes bursts the veins of the brain, neck, intestines, kidneys, and lastly of the lungs
and

and right auricle of the heart. This occasions prodigious anxiety and uneasiness to the spirits; this also is the cause of death in compressed air, in drowned people, and such as are strangled, which is much more sudden than is commonly imagined. A living person therefore, that he may remove those inconveniences which flow from an obstruction of the passage of the blood, slackens the powers of inspiration, and excites those of expiration, which free the breast from an air too greatly rarefied.

These powers are, first, the elasticity of the ribs; which being drawn upwards out of their natural situation, as soon as the powers which elevated them cease to act, spontaneously place themselves, so as to make more acute angles with the sternum and vertebræ. To this end conduces likewise the elastic force of the bronchia and vesicles distended with air, which strive to contract themselves. Hence expiration is performed more easily and quickly than inspiration; and hence it is the last action of dying people.

To this also contribute the oblique muscles of the abdomen, together with the straight and transverse ones. The former of these are, in one part of them, fastened to the lower ribs; and, in another part, they are attached to the os pubis and ilium, as a fixed point with respect to the breast. Therefore the straight muscles, being contracted, depress the arch or convexity, into which the abdominal viscera are thrust by the diaphragm, and bring the same nearer to a straight line: at the same time the abdominal viscera are pressed by those muscles upward and backward against the diaphragm, which alone is able to give way; and yield up into the thorax, which at that time is rendered shorter. The oblique muscles, for the same reasons, compress the lateral parts of the abdomen, and urge the liver and stomach backwards, and press them towards that place where there is the least resistance. Lastly, they draw down the ribs which were before elevated by the intercostals. The transverse muscles, indeed, do not

draw the ribs ; but they pull the cartilages of the false ribs a little inward, and render the whole capacity of the abdomen less, while at the same time they press the viscera against the diaphragm. Along with these we may reckon the powers of the sternocostal and long intercostal muscles, which are called *depressors*. By this joint force the superior ribs descend ; but the middle ones more, the uppermost less, the lowest most of all ; and the same are brought inwards by their margin : the cartilages ascend, and return into acute angles with the sternum ; and the sternum itself returns backwards with the ribs. By these means the thorax, contrary to its former state, is every where rendered narrower and shorter, so as to expel as much air out of the lungs as is sufficient to relieve the uneasiness caused by its retention.

In more powerful respirations, when the inspirations are made greater, the expirations are likewise increased by the assistance of some other powers, as of the sacrolumbalis, longissimus and quadratus muscles of the back and loins. This force, by which the air is blown out of the lungs, is sufficient to carry a leaden bullet, weighing about a dram, to the distance of 363 feet ; which force is equal to a third part of the pressure of the atmosphere. But, in a healthy person, the muscles of the abdomen alone suffice to an easy expiration, in which the lungs are not so much emptied of air as they are by a violent efflation.

The effects of expiration are, a compressure of the blood-vessels in the lungs, a reduction of the bronchia into more acute angles, a pressure of the reticular small vessels by the weight and contact of the adjacent larger vessels, and an expulsion of the corrupted blood from the lungs ; by which means part of the blood hesitating in the capillary arteries, is urged forward through the veins to the left side of the heart, while at the same time that part of the blood is resisted which flows in by the artery from the right ventricle. Expiration, there-

therefore, will stop the easy passage of the blood thro' the lungs; and when the whole thorax is compressed together, repels the venous blood into the veins of the head, and fills the brain and its sinuses.

In this manner a fresh necessity follows for repeating the respiration; because the collapsed vessels of the lungs resist the blood repeatedly expelled from the right ventricle of the heart. And this makes another cause of death in those animals which expire in vessels exhausted of air: for, in such, the lungs having the air drawn out from them, appear dense, solid, and heavier than water; whence they are rendered impervious to the blood. Of the same kind is the death of those who are killed by lightning, and perhaps by the noxious vapours of caverns. Thus, therefore, by the power of a most wise fabricature, the organs of expiration are relaxed so soon as that uneasiness is perceived, which arises from the hindrance of the blood's course through the lungs; and hence the powers of inspiration are excited into action, whereby the motion of the blood through the lungs is rendered free and quicker.

It is by some questioned, Whether or no there are not other causes of alternate respiration? Whether or no we may hope for any discovery in this matter, by compressing the vena sine pari, the phrenic nerve, or intercepting the blood sent to the brain? But those are repugnant to comparative anatomy; by which we always find the same alternation in the breathing of the animal, independent of any such nerve or vein. Whether or no respiration is from the alternate contraction of the antagonist muscles, among which those of expiration relax the others of inspiration, and the reverse? But in this manner, all the muscles of the human body are perpetually in an alternate motion.

From what has been hitherto said, it appears, that respiration is unavoidably and absolutely necessary to life in a healthy adult person; because, whether the lungs remain long in a state either of expiration or
inspi-

inspiration, we see death will be the consequence. Therefore no animal that has lungs like ourselves, after it has once breathed and received the air into the inmost parts of the lungs, and by that means brought a new and large quantity of blood to that viscus, can subsist longer than a few minutes without the use and benefit of a free air; but it will either perish, or at least fall into such a state as differs from death only in its being recoverable again by certain powers or actions. In an animal lately born, this necessity for air does not take place so suddenly.

But the use of respiration is different from this necessity; which nature might have avoided, either by using no lungs at all, or else by disposing them in a manner resembling those of the foetus. This use, therefore, of respiration must be very considerable, since all animals are either made with lungs, or with gills, as in fish, or else with a windpipe dispersed thro' all parts of the body.

In order to discover this usefulness of respiration, let us compare the blood of an adult person to that of a foetus, and also with the same vital fluid in fish. It appears then in a foetus, that the blood is destitute of its florid redness and solid density; and in the blood of fish, we observe there is no heat, the density inconsiderable, and but little crassamentum contained in it; and, therefore, all these properties, we are, by the nature of things, persuaded, the blood acquires in the lungs.

It may be asked, therefore, Whether the blood does not acquire its heat principally in the lungs? But this does not arise from the alternate extension and contraction, relaxation and compression, of the pulmonary vessels, by which the solid parts of the blood are perpetually rubbed and closely compressed? The lungs therefore will add to the office of the rest of the arteries, because in them the blood is alternately relaxed and compressed more than in any other part of the body. But even
when

when the lungs are obstructed, ulcerated, and almost destroyed, a morbid heat seizes upon the body : but in the lungs the cold air very nearly touches the blood.

The density of the blood is, indeed, again promoted in the lungs, partly by the copious discharge of the watery vapour which is there separated, by which the rest of the mass becomes specifically heavier. But the same effect seems to follow here, as in other arteries, namely, from the attrition and pressure which the blood here suffers in being alternately retarded, accelerated, and figured in its course through the modulating tubes of the least vessels, which give a sphericity and density to the particles ; hence it becomes denser, as having more of the weighty globules, and less of the lighter fluid. And, in this respect, the pulmonary vein, being smaller than its corresponding artery, is of no small use towards increasing the attraction of cohesion betwixt the parts of the globules, so as to compress and bring them closer to each other. Nevertheless, cold animals, which have very small lungs, have dense and coagulable blood ; as also a chicken before it is hatched. The blood also has a short passage through the lungs : the passage through the whole body is longer, and the artery weaker ; the heart, by which the blood is driven forward, is also weaker.

It is therefore queried by some, Whether the air itself is not received by the blood in the lungs, so as to excite necessary vibrations therein ? Whether this does not appear from the resistance of bodies to the heavy external air ; and from the air found in the blood-vessels, in the cellular substance, and in certain cavities of the human body ; also from the cracking observed by an extension of the joints ; to which add the air manifestly extravasated from the windpipes into the hearts of certain animals, as in the locust ; from air coming out of the blood and humours of animals in Mr Boyle's vacuum ; together with a necessity of a vital
of-

oscillation in the blood itself; and, lastly, the increased redness of the pulmonary blood?

But that no elastic air is here received into the blood, is demonstrated from the impossibility of forcing air into blood, if it retains its elasticity; from the inutility of its reception, if the spring of it should be lost in the blood; from the perfect immutability of the blood, by cold; from the minuteness of the inhaling vessels, with the mucus that perpetually lines the sides of the vesicles in the lungs: to which add the nature of the elastic air itself, which is very unapt to pass through capillary vessels; with a repulsion of it by water, that hinders it from passing through paper, linen cloth, or skins that are wetted by water. Again, the air being driven into the wind-pipe, never passes to the heart; or whenever it does, it is forced thither by some great or unnatural violence: but the permanent air in the vessels and humours of the human body, from a state of inelasticity, may become elastic by putrefaction, frost, or an external vacuum. But such permanent unelastic air is incorporated with all liquors; and taken into our bodies with the aliments and with absorbed vapours, mixing slowly and with some difficulty. But there never were any elastic bubbles of air observed in the blood of a living animal; and such air being inflated into the blood-vessels of any living animal, kills it certainly and speedily. Lastly, though air indeed is absorbed by most of our humours, yet that absorption is performed slowly, and takes up the space of several days after the former air has been exhausted by the pump. It then likewise lays aside its elastic nature; nor is there any reason produced, why the air should either be more speedily absorbed by the blood, or why it should retain its elasticity after it is so absorbed.

“ In these our times (says Wrisberg), it is now too much a matter of dispute, as if it were a subject entirely new, I mean the different kinds of air; to wit, fixed, inflammable, narcotic, nitrous, &c. which were partly known

known to Helmont, Newton, Boyle, Camerarius, Hales, and several others; but the pneumatic theories in general have been remarkably elucidated, increased, and limited, as occasion required, by the laudable industry of Drs Brownrigg, Black, Cavendish, Priestley, Spielman, Erxleben, &c. If, in a few words, I might offer my opinion about the air found in our bodies, which has been the basis of so many disputes, I am persuaded, that the atmospheric air is a very compound fluid, consisting of parts of a very different nature and quality; which parts when mixed with any primigeneous fluid as a vehicle, make the common air we inhale in inspiration. This primigeneous fluid is, perhaps, that air which we observe in animals, vegetables, and likewise in the earth itself, differing only according to the various substances with which it is united. If there is mixed, in a due proportion with this universal fluid, any elastic, ethereal, electric principle, or any particles not yet fully understood, perhaps there will result salubrious atmospheric air. But it will become infected and noxious in various degrees, from an admixture of putrefactive substances, narcotic or inflammable suffocating elements. For that reason it seems to me very proper, that our judgment about the salutary or noxious quality of the air should be directed by these principles; and hence it will be in our power to correct unwholesome air, provided we know what qualities the air should possess which is most properly suited to the function of respiration."

Whether or not is the blood cooled in the lungs? and whether or not does this seem to be true from the death of animals, in air which is hot to such a degree as equals the heat of the hottest breezes in the most sultry dog-days? Whether the pulmonary veins are not, therefore, less than the arteries; and whether the desire of cold in people that are working hard does not arise from thence? That the blood is cooled in the lungs is thus far true, as it warms the contiguous air,
and

and therefore loses something of its own heat. But that this was not the principal design of nature, is evident; since no one will say that the venous blood is hotter than the arterial, although some pronounce the former to be somewhat cooler; but nobody ever observed the left ventricle of the heart cooler than the right. But the venous blood enters the lungs; if it be there cold, it will follow, that the arteries must receive it in still a colder state. But then here the degrees of heat which the blood communicated to the air are again recovered by it. And, indeed, a person may live in an air much hotter than the blood itself; of which we have a familiar example in baths and the warm countries. The pulmonary artery in a foetus, which does not respire, is greater; and the larger area of the right auricle and ventricle of the heart, is likewise much greater in a foetus; which seems necessary to reserve and retard the blood, as the pulmonary vein being narrower accelerates it.

Whether or not is the redness of the blood produced from the air? This is contradicted by what we see in cold animals, which, though they are almost entirely deprived of the use of air, have blood equally red with that of warm animals; from the certain connection of redness in the blood of frogs with their having plenty of food, and a paleness of it with a want of food; and from the air, as we have just now said, being denied access to the blood. Nevertheless, redness is produced when the air has access to the blood, by which means it is also restored after it has been lost; and, on the other hand, it is destroyed by the denial of the access of air. Whether or not may not a more subtle element from the air penetrate the blood, and be the cause of its colour, as light is required for the colours of plants?

Whether the use of the lungs is to absorb a nitre from the air to the blood? or whether the florid colour, observable in the surface of a cake of blood, be

owing to the same cause, while the bottom part looks of a dark and blackish colour? and whether or not this is a preservative against the putrefaction of the animal? remain as questions with some. That there is a kind of volatile acid in the air is certain, since that meeting with a suitable earth forms nitre; for a nitrous earth, being exhausted of its salt, and exposed again to the air, becomes re-impregnated with more nitre. But the same universal acid, we know by certain experiments, meeting with a different sort of earth, forms a vitriolic salt, or alum, or else sea-salt. For the caput mortuum of sea-salt, which remains after the distillation of the spirit, recovers so much strength from the air, as enables it to yield more spirit by distillation; even in snow there is a cubical salt: but marcasite perspires a true vitriol; and colcothar recovers again the acid spirit which was drawn from it; also fixed alkali, exposed to the air, turns into a vitriolated tartar. This, therefore, cannot be the use of respiration, because those salts abound in too small a quantity in the air for such uses; and air is fittest for breathing when pure in high mountains, where those salts are the least to be found; nor is there any nitrous salt as yet known to be found in our blood.

If it be asked, Why tortoises, frogs, lizards, snails, ear-wigs, and other insects, live long without air? we answer, That in them the lungs are given not so much for the preparation of the blood, which they receive but in a very small quantity, as for the use of swimming in the water: and from hence it is that their lungs are immediately joined with the vena cava and aorta. But insects, we know, draw the air in, and exhale it again, through points in the skin. If it be asked, Why all animals perish in air that is confined or not renewed, although the animal be small, such as little birds? we answer, Because the air, which has once entered the lungs, and been fouled by watery vapours, is rendered less elastic, and unfit for respiration, by alkaline vapours:

vapours : not because it becomes lighter ; for the mercury falls but little in air which has not been renewed, and which has killed an animal. Hence it is that the animal survives longer in air that is more compressed than that of the atmosphere : for in that case there is a greater proportion of the elastic element, which takes up a longer time to corrupt. But, even in other cases, confined air is rendered destructive only by stagnation, and filling it with vapours. But the reason why animals swell in an exhausted vessel, is, from the extrication and expansion of the unelastic air lodged in the blood and other juices.

There is a certain consent or proportion between the pulse and respiration ; so that, according to the common course of nature, there are three or four pulses counted to one respiration. But if more blood is sent to the heart in a given time, the numbers both of the pulse and respiration are increased. This is the reason of the panting or short breathing in a person that exercises his body with any considerable motion ; whereby the venous blood is returned faster to the heart. But if the blood meets with a greater resistance in the lungs, so that it cannot pass freely from the right into the left ventricle of the heart ; then respiration is increased, both in number and magnitude, in order to forward its course : and this is the cause of sighing, yawning, and wheezing ; of which the first is a deep inspiration ; the second slow, and very great ; and the third, a frequent and imperfect one. The number of respirations, however, does not always increase with the pulse ; of which we have an example in those fevers where the lungs are not affected.

The mucus, which lines the sensible membranes of the air-vessels in the lungs, may become troublesome both by its quantity and acrimony ; it has been known to cause even suffocation in a dropsy of the lungs. Therefore its quantity, adhesion, or acrimony, excites a cough ; namely, an irritation of the respirative system,

stem, by alternate large inspirations, succeeded by large and quick expirations, together with sudden shocks of the abdominal muscles; by which the mucus, and sometimes calculous matters, are expelled from the lungs.

Laughter differs from coughing in its cause, which resides commonly in the mind, or at least consists in a certain titillation of some of the cutaneous nerves; and, moreover, because it is made up of imperfect quick expirations through the contracted glottis, lest the air should be totally evacuated from the lungs. Hence laughter, in a moderate degree, conduces to health; because, in the time of one full inspiration, many short inspirations and expirations happen, and thus the concussion is greater. Hence its danger of stagnating the blood; because the expiration is not full or entire, whereby the blood is admitted into the pulmonary artery without being suffered to pass through it. Weeping begins with a great inspiration, after which follow short alternate inspirations and expirations; and the same is finished with a deep expiration, that is immediately joined by a large inspiration: hence it has nearly the same good and bad effects; and, when moderate, it conduces to relieve the anguish arising from grief. An hiccup is a very great, sonorous, and sudden inspiration. Sneezing consists of one large or deep inspiration, which is followed immediately with a powerful and sudden expiration; and the acrid matter is blown out by it in some quantity from the nostrils.

The secondary uses of respiration are very many. It exhales, as an emunctory, parts redundant, or even noxious, from the blood, which would suffocate, if they remained in the air; and the breath of many people, shut up in a close place, impregnates the air with a suffocating quality. On the other hand, it absorbs from the air a thin vapour, of which the use is perhaps not sufficiently known.

“ Among

“ Among the uses of respiration (says Wrisberg), seeing several of them are accounted of the same importance, may be counted the power of resorption; by which the lungs absorb by means of their vessels, from the air inhaled in inspiration, not only vapours mixed with the air, but mingle with our humours by means of the foramina, ducts, and proper canals, some other by far nobler parts, constituting, at the same time, one of the elements of the air.

“ This substance has got no proper name; nor do we know the nature of the part which is principally referred, in the first place, to the elements of the air, and, next, to our humours and blood. The once celebrated *pabulum vitæ* was an ingenious denomination, seeing, as has often happened, many persons confined in narrow spaces, unless free access of air is procured, have run the risk of their life, from their wanting a proper renewal or *pabulum* of air. But the name of *electric principle*, if we consider the whole consent of nature, seems more fitly adapted to the subject. For since the publication of the famous observations made by Gilbert, Guericke, Boyle, the Florentine academicians, Hawksbee, Du Fay, Muschenbroeck, Watson, Ludolph, Winckler, Nollet, Franklin, Hartman, Priestley, and several others, both about the electricity of bodies in general, as well as of the atmosphere in particular, the whole doctrine, by means of the new machine, the electrometer, from the experiments of Volta, Wilson, Wilkenius, his serene highness Gallitzin, Lightenberg, &c. has received so great additions, that it might almost be asserted, that the electric matter of the air is collected in the most simple manner by almost every body. From all those experiments we collect,

“ 1. That there is in the air a fluid which, in different ways, may be increased in one place, and diminished in another; which, when collected *secundum artem*, exhibits electric sparks; but, when collected in the clouds, breaks forth in lightning and thunder.

“ 2. If from its too great congestion in any region of the atmosphere or in the clouds, the circumambient air wants its due proportion, our respiration is less refreshing, our strength grows languid; but they are quickly renewed after a thunder-storm, the equilibrium of the electric matter in the atmosphere being effected, as it were, by the flashes of lightning.

“ 3. Perhaps, too, we learn a method, and the remedies, by which we may artificially remove this defect: it is worth while at least to consider of this.

“ 4. This electric matter passes into the blood or lymph by innumerable pores and foramina, with which the inside of the larynx, aspera arteria, and bronchia, abound. Upon the diversity of these holes, both with respect to number, condition, and mucus, with which they may be covered, and to the size of the lungs, depends the reason why all men cannot inhale and absorb the same quantity of electric matter from one and the same air.

“ 5. It will not be easy for any person, in an affair destitute of sufficient observation, to unravel what use this substance serves in animal bodies, and what functions depend upon it. Whether is the tone and irritability of the fibres of the body principally supported by it? Do the increase and causes of animal heat proceed from it? I think it is clear, we ought hence to seek the cause of animal electricity; which is very conspicuous in cats, and likewise horses, and many men, by the numerous sparks which may be made to appear issuing from their bodies. This is perhaps the cause of the greater danger to which some men are liable of being struck with thunder. The spontaneous burning of some bodies in nature are undoubtedly to be ascribed to the same cause; and the alacrity and vigour of some temperaments surely is wonderfully increased by the presence of this fluid. May this substance be joined with the acidum pingue and inflammable principle?”

It is by this force that the abdomen and all its viscera

cera are continually compressed; by virtue of this, the stomach, intestines, gall-bladder, receptacle of the chyle, bladder of urine, intestinum rectum, and the womb itself, discharge their contents; by this action the aliments are principally ground or dissolved, and the blood is urged through the sluggish vessels of the liver, spleen, and mesentery. It excites a kind of flux and reflux in the blood, so that it is alternately pressed back towards the extremities of the veins, and a little after is propelled towards the heart by an accelerated velocity, as into an empty space. Moreover, inspiration serves to convey odours along with the air to the organs of smelling. By this, the air is mixed with the aliments; which it conduces very much to break and dissolve towards a perfect digestion. But even sucking, so necessary to the new-born infant, is made by the use of respiration, and forming a larger space in the mouth, in which the air is rarefied; so that, by the greater pressure of the outward air, the milk is driven into that part, where it is less resisted. Lastly, the voice itself is owing to the air which we breathe; as was explained in a former part of the work.

§ II. *Oesophagus.*

Situation and figure. THE oesophagus is a canal partly muscular and partly membranous; which commences at the inferior part of the pharynx, and descends along the neck and back part of the thorax into the abdomen. While it lies in the neck, it is placed between the middle and left part of the cervical vertebræ behind the left part of the trachea; in the thorax, it is situated between the layers of the posterior mediastinum, and descends to the fourth or fifth vertebra of the back, in the same direction which it had above: there it inclines a little from left to right, till it reaches the ninth rib, to make way for the aorta; afterwards it inclines from right to left, and from behind forward,

to get through the diaphragm into the upper orifice of the stomach.

Structure and coats. It is made up of several coats almost in the same manner as the stomach, of which it is the continuation. The first coat, while in the thorax, is formed only by the duplicature of the posterior part of the mediastinum, and is wanting above the thorax and in the neck, where the outer coat of the œsophagus is only a continuation of the cellular substance belonging to the neighbouring parts.

The second coat is muscular, being made up of several strata of fleshy fibres. The outermost are mostly longitudinal, and their quantity is much greater than that on the rest of the alimentary canal; but they are not all continued from one end of the œsophagus to the other. The following strata are obliquely transverse, and the innermost are turned a little obliquely the contrary way. They cross each other irregularly in many places, but are neither spiral nor annular.

The third is termed the *nervous coat*, and is like that of the stomach and intestines. It is differently folded or plaited, according to its length, being much wider than the muscular coat; and it is surrounded by a whitish, soft, fine filamentary substance, like a kind of cotton, which, when steeped in water, swells and grows thicker.

The fourth or innermost coat resembles in some measure that of the intestines; except that, instead of the villi, it has small and very short papillæ. It is folded lengthwise like the third coat; so that the œsophagus, when cut across, represents one tube within another. Through the pores of this coat, a viscid lymphæ is continually discharged.

The upper end of the œsophagus is supplied with arteries from the laryngææ inferiores; farther down it has branches from those which supply the pericardium; the rest of it is supplied by the arteriæ bronchiales. The veins go into the superior laryngeals, to the top
of

of the superior vena cava, to the vena azygos and bronchial veins.

The nerves are chiefly from the eighth pair : some small branches come from the great sympathetics.

§ 12. *Ductus Thoracicus.*

THE thoracic duct is a thin transparent canal, which runs up from the receptaculum chyli along the spina dorsi, between the vena azygos and aorta, as high as the fifth vertebra of the back, or higher. From thence it passes behind the aorta toward the left hand, and ascends behind the left subclavian vein, where it terminates, in some subjects, by a kind of vesicula, in others by several branches united together, and opens into the back-side of the subclavian vein near the outside of the internal jugular.

This canal is plentifully furnished with semilunar valves turned upward. Its opening into the subclavian vein is covered by valves, so disposed as to permit the entrance of the chyle into the vein, and hinder the blood from running into the duct. It is sometimes double, one lying on each side ; and sometimes it is accompanied by appendices, called *pampiniformes*.

C H A P. III.

Of the ABDOMEN.

THE whole fore-part of the abdomen forms an oblong convexity like an oval vault, more or less prominent in the natural state, in proportion to the quantity of fat upon it and of food contained in it, or to the different degrees of pregnancy in women. The hypogastric and umbilical regions are more subject to these varieties than the epigastric region.

On the sides, between the hypochondria and ossa ilium or haunch, the abdomen is commonly a little contracted; and backward, about the middle of the regio lumbaris, it is gently depressed, forming a kind of transverse cavity, answering to the natural incurvation of the lumbar portion of the spina dorfi.

This anterior convexity, and posterior cavity, change as we sit, stand, kneel, lie at our full length, or with the thighs bent; and these variations depend on the particular situation of the ossa innominata in these different postures.

In standing, the convexity of the belly, and cavity of the loins, are more considerable than in most other situations; for then the lower extremity of the os sacrum is turned very far back, and consequently the os pubis very much down. In this situation of the pelvis, the intestines fall naturally forward, and thus increase the convexity of the abdomen; and as the vertebræ of the loins are very much bent at the same time, the cavity in that place must likewise be very considerable.

In kneeling, the ossa pubis are still lower than when we stand: and this not only increases the hollow of the loins, and throws the abdomen and its viscera more outward or forward, but also in some measure strains the
the

the abdominal muscles; which is so uneasy to some persons, as to cause them to faint away.

This depression of the os pubis in kneeling depends partly on the tension of the two muscoli recti anteriores; the lower tendons of which are, in this situation, drawn with violence under the condyloide pulley of the os femoris.

When we sit in the common manner, that is, with the thighs stretched out in a plane parallel to that of the seat, the convexity of the belly and hollow of the loins diminish.

For the pelvis being in this situation supported on the tubercula ischii, and these tubercles being very near the fore-part of the pelvis, the trunk of the body pressing on the os sacrum must lower the pelvis behind, and raise it before.

When we lie upon the back at full length, and with the thighs extended, the belly is less convex, but more stretched and hard; whereas, when the thighs are bent, it is soft and lax. In this situation, the regio lumbaris is almost flat and very little depressed.

When we lie on the back, and raise the head, or endeavour to raise it, we feel a tension in the fore-part of the abdomen, which increases in proportion to the force we use in raising the head.

Integuments of the abdomen. The anterior portion of it is not only thinner and more compact than the posterior, as has been already observed, but it has this likewise peculiar to it, that it may be naturally increased very much in breadth, and sometimes in a very extraordinary manner, without losing any thing of its thickness, in proportion to what it gains in breadth.

The cells of the membrana adiposa, which covers the convex part of the abdomen, are disposed in a very regular manner, as we discover by dissecting the skin from the muscles; for then there appears on the inner surface of the membrana adiposa a longitudinal line like a kind of raphe, produced by the meeting of the cellular

lular rows, which form angles successively, one above another, opposite to the linea alba of the abdomen. The cells in these rows are more oblong than the rest, and in a manner oval, or like a grain of wheat.

Cavity of the abdomen. The appendix ensiformis of the sternum, the cartilaginous portions of the last pair of true ribs, those of the first four pairs of false ribs, all the fifth pair, the five lumbar vertebrae, the ossa innominata, the os sacrum, and os coccygis, form the bony sides of the cavity of the abdomen.

The diaphragm, the muscles called particularly *musculi abdominis*, the *quadrati lumborum*, *psoai*, *iliaci*, the *muscles of the coccyx*, and of the *intestinum rectum*, form the chief part of the circumference of this cavity; and its whole inner surface is lined by a membranous expansion, termed *peritoneum*, all these parts being covered by the integuments already spoken to. As additional or auxiliary parts, we might likewise add some portions of the sacro-lumbares, longissimi dorsi, vertebrales, glutæi, &c.

The cavity of the abdomen is of an irregularly oval figure, but still symmetrical. On the fore-side it is uniformly arched or oval, and its greatest capacity is even with the navel and nearest part of the hypogastrium. On the upper side it is bounded by a portion of a vault, very much inclined. On the back-side it is in a manner divided into two cavities by the jetting out of the vertebrae of the loins. On the lower side, it contracts gradually all the way to what I call the *little edge* of the pelvis; and from thence expands again a little as far as the os coccygis, and tubercles of the ischium, terminating in the void space between these three parts.

§ 1. *Peritoneum.*

HAVING carefully removed the muscles of the abdomen, the first thing we discover is a very considerable membranous covering, which adheres immediately to the

the inner surface of the muscoli transversi, and of all the other parts of this cavity; and involves and invests all the viscera contained therein, as in a kind of bag. This membrane is named *peritonæum*, from a Greek word, which signifies to be spread around.

The peritonæum, in general, is a membrane of a pretty close texture, and yet very limber and capable of a very great extension; after which it can recover itself, and be contracted to its ordinary size; as we see in pregnancy, dropsies, corpulency, and repletion.

It may be looked upon as a single membrane, although it has been described by many anatomists as a duplicature of two distinct membranous laminæ. But, properly speaking, the internal portion alone deserves the name of a *membranous lamina*, as being the main body of the peritonæum. The external portion may properly enough be termed the *cellular substance of the peritonæum*.

The inner surface of the peritonæum is very smooth, and polished on that side which is turned to the cavity and viscera of the abdomen, and continually moistened by a serous fluid discharged through almost imperceptible pores.

These pores may be seen by spreading a portion of the peritonæum on the end of the finger, and then pulling it very tight on all sides; for then the pores are dilated, and small drops may be observed to run from them, even without a microscope.

The sources of this fluid are chiefly from the exhalent vessels. The whitish corpuscles found in diseased subjects are no proof of the glands, which some anatomists place there in the natural state.

The cellular substance, or external portion of the peritonæum, adheres very closely to the parts which form the insides of the cavity of the abdomen; and it is not every where of an equal thickness. In some places it is in a very small quantity, and scarcely any appears at
the

the tendinous or aponeurotic portions of the muscoli transversi, and on the lower side of the diaphragm.

In all other places it is thicker, and forms cells expanded into very fine laminæ, which, in diseased subjects, become sometimes so broad and thick, as to resemble so many distinct membranes.

In some places, this substance is every way like a *membrana adiposa*, being filled with fat, as round the kidneys, and along the fleshy portions of the transverse muscles, to which it adheres. It entirely surrounds some parts, as the bladder, ureters, kidneys, spermatic vessels, &c. and it is in these places improperly termed the *duplicature of the peritonæum*.

Besides these differences in thickness, the cellular substance has several elongations, which have been called *productions of the peritonæum*. Two of these productions accompany and invest the spermatic ropes in males, and the vascular ropes, commonly called the *round ligaments*, in women. There are other two, which pass under the ligamentum Fallopii, with the crural vessels, which they involve; and they are gradually lost in their course downward.

To these four productions of the cellular substance of the peritonæum we may add a fifth, which is spread on the neck of the bladder; and perhaps a sixth, which accompanies the intestinum rectum. All these elongations pass out of the cavity of the abdomen, and may be termed *external*, to distinguish them from others that remain in the abdomen, and are called *internal*; of which hereafter.

The great blood-vessels, that is, the aorta and vena cava, are likewise involved in this cellular substance of the peritonæum. In a word, it involves immediately and separately all the parts and organs which are commonly said to lie in the duplicature of the peritonæum.

The true lamina, or membranous portion of the peritonæum, is connected by the intervention of the cellular substance to the inner surface of the cavity of the

abdomen; but it does not naturally accompany the external elongations of that substance. It only covers the origin or basis of these productions, without any alteration in its own surface at these places.

It has, nevertheless, productions of its own; but they are very different from those of the cellular substance; for they run from without inward, that is, they advance from the convex side of the great bag of the peritonæum into the cavity of that bag, some more, some less, and also in different manners, as if the sides of a large ball or bladder were thrust inward into the cavity of the ball or bladder.

Of these internal elongations of the peritonæum, some are simply folded like a duplicature; some are expanded like inverted bags, or sacculi, to contain some viscus; some begin by a simple duplicature, and are afterwards expanded into a cavity which contains some organ; some are alternately extended in the form of simple duplicatures and of cavities; and, lastly, some form only a small eminence on the inner surface of the great cavity of the peritonæum.

Under the first species of these productions, we may bring the membranous ligaments of the abdomen, such as those of the liver, colon, &c. We see the second species in the external membrane of the liver; the third in the mesentery; the fourth in the mesocolon; and the fifth at the kidneys and ureters.

Besides the external productions of the cellular substance of the peritonæum, it has the same number of internal elongations with the true lamina; which lie between all the duplicatures, and line the insides of all the cavities, or that side next the viscera contained in them.

The vessels and nerves of the peritonæum are from those that supply the neighbouring parts. The arteries come from the *mammariæ internæ*, the *intercostales inferiores*, the *lumbares*, the *arteriæ sacræ*, the *ilio-lumbares*, the *epigastricæ*, the small anterior iliacs, the
inferior

inferior diaphragmatics, and from the vessels which supply the abdominal viscera. The veins corresponding with these arteries have the same course and bear the same names. The nerves of this membrane are few in number, and small: they come from the great intercostals from the lumbar and sacral.

The uses of the peritonæum, in general, seem to be very evident from the description which has been given of it: and the chief of these uses are, to line the cavity of the abdomen, to invest the viscera contained in that cavity as in a common bag, to supply them with particular coats, to form productions, ligaments, connections, folds, vaginæ, &c. as we shall see hereafter.

The fine fluid which transudes through the whole internal surface of the peritonæum prevents the inconveniences which might arise from the continual frictions and motions, to which the viscera of the abdomen are exposed, either naturally or by external impulses.

We must here observe, that it is the common custom to demonstrate four ligamentary ropes, termed the *umbilical vessels*, before the peritonæum is opened, because they adhere to the umbilicus; and three of them are really vessels in the fœtus, viz. two umbilical arteries and one vein. We are in a manner obliged to submit to this custom in public anatomical demonstrations, where we have but one subject for the whole; but as we are here under no such necessity, we refer the description of these ligaments to other more proper places of this work. The venal ligament shall be described in the history of the liver; and the two arterial ligaments, together with the urachus, which is the fourth, in the history of the bladder.

It is sufficient to observe here in general, that three of these umbilical ropes or ligaments are involved separately, and sustained by a production or duplicature, which the peritonæum sends into the cavity of the abdomen in form of a falx.

§ 2. *Ventriculus.*

Situation and figure of the stomach. THE stomach is a great bag or reservoir, situated partly in the left hypochondrium, and partly in the epigastrium.

The figure of the stomach is like that of a bag-pipe; that is, it is oblong, incurvated, large, and capacious, at one end, and small and contracted at the other. We see this figure most evidently when the stomach is moderately filled with air or with any other fluid.

The curvature of the stomach gives us occasion to distinguish two arches in it; one large, which runs along the greatest convexity; and one small, directly opposite to the former. These arches are named the *great* and *small* curvatures of the stomach; and by the sides of the stomach, we understand the two lateral portions which lie between the two arches.

The stomach has two extremities; one large and one small. It has two openings, called the *orifices of the stomach*; one between the great extremity and the small curvature, the other at the end of the small or contracted extremity. The first opening is a continuation of the œsophagus; the other joins the intestinal canal, and is called by the name of *pylorus*.

The stomach is not situated in the left hypochondrium and epigastric region, in the manner represented in most of the figures. It lies transversely, obliquely, and almost laterally; in such a manner as that the great extremity, and the orifice next it, are on the left hand; and the small extremity, with its orifice, or the pylorus, on the right hand, and lower and more inclined than the former: Therefore we ought, with the ancient anatomists, to call one of these orifices *superior*, the other *inferior*.

The great extremity of the stomach is in the left hypochondrium, and for the most part immediately under the diaphragm: yet the superior orifice is not in the left

hypochondrium, but almost opposite to, and very near the middle of, the bodies of the lowest vertebræ of the back.

The small extremity of the stomach does not reach to the right hypochondrium. It bends obliquely backward toward the upper orifice: so that the pylorus lies about two fingers breadth from the body of the vertebræ immediately under the small portion of the liver; and consequently lower down, and more forward, than the other orifice by almost the same distance. This extremity of the stomach has sometimes a particular dilatation on the side next the great curvature.

According to this natural situation, the stomach, especially when full, is situated with its great curvature forward and a little downward, and its small curvature backward and a little upward.

One of the lateral convex sides is turned upward, the other downward; and not forward and backward as they appear in dead bodies, where the intestines do not support them in their natural situation.

If we divide the stomach along the two curvatures into two equal parts, we shall see that the two orifices do not both adhere to the same half of this division, as we would be apt to imagine according to the common notion; but that the diaphragmatic orifice is entirely in the upper half, and the intestinal orifice in the lower.

Therefore the body of the stomach is so far from lying in the same plane with the œsophagus, as it is commonly represented in figures drawn from a stomach taken out of the body and laid upon a table, that it forms an angle or fold immediately at the passage of the œsophagus through the small muscle of the diaphragm; and it is on account of this angle that the superior orifice is turned backward.

Structure of the stomach. The stomach is composed of several parts; the chief of which are the different strata which form its substance, to which anatomists give the name of *tunicæ* or *coats*. These coats are commonly reckoned

reckoned to be four in number; the outer or common, the fleshy or muscular, the nervous or aponeurotic, and the villous or inner coat; and they are afterwards subdivided several ways.

The first or outermost coat is simply membranous, being one of the internal productions of the peritonæum. This appears evidently at the connection of the superior orifice with the diaphragm, where the external membrane of the stomach is really continuous with the membrane, which lines the inferior surface of the diaphragm; and it is from this that it has been named the *common coat*.

The second or muscular coat is made up of several planes of fibres, which may all be reduced to two; one external, the other internal. The external coat is longitudinal, though in different respects following nearly the direction of the curvatures and convexities of the stomach; and the internal plane is transversely circular.

The fibres of the external plane run slanting in several places; and are intersected by small oblique whitish lines, which seem to be in some measure tendinous. This plane is strengthened by a particular fasciculus which runs along the small curvature, its fibres appearing to be less oblique than those of the great plane.

The fibres of the inner or circular plane of this muscular coat are stronger than those of the outer plane. They are rather segments which unite at different distances, than entire circles; and they are likewise intersected by great numbers of small white lines, in some measure tendinous and very oblique, which all together represent a kind of net-work, the *areolæ* or meshes of which are very narrow.

As these circles or segments advance on the great extremity of the stomach, they diminish gradually, and form a kind of muscular vortex; the centre of which is in the middle of that extremity.

Between the outer and inner planes, round the superior orifice, there are two distinct planes about the

breadth of a finger, and very oblique, which surround this orifice in opposite directions, and intersect each other where they meet on the two lateral sides.

Along the middle of each lateral side of the small extremity, there runs a tendinous or ligamentary flat portion, above a quarter of an inch in breadth, which terminates in the pylorus. These two portions lie between the common and muscular coats, and adhere very strongly to the first.

Between the two same coats, there is a cellular substance which adheres very closely to the external coat, and insinuates itself between the fleshy fibres of the second, all the way to the third, as may be perceived by blowing it up. Some make it a distinct coat, and call it *tunica cellulosa*; but it is no more than the cellular portion of the membranous coat, like the cellular portion of the peritonæum.

The third coat, called commonly *tunica nervosa*, but properly *tunica cellulosa*, is composed of capillary vessels and nerves, with a very large proportion of cellular substance. On the concave side it seems to be of a very loose spongy or filamentary texture, resembling fine cotton, as may be seen by macerating it a little in clear water, which swells it considerably in a very short space of time. It is supported by a kind of groundwork of a very fine ligamentary or aponeurotic filaments which intersect each other obliquely, much in the same manner as the third coat of the intestines, of which hereafter; and it adheres to the convex side of the villous coat.

The fourth coat of the stomach has been termed by Fallopius *tunica villosa*, because, when it swims in clear water, something is seen in it like the pile of velvet. The ancients called it *tunica fungosa*; and perhaps this name agrees best with its true structure.

These two coats are of a larger extent than the two former, and they join in forming large rugæ on the
concave

concave surface of the stomach; the greatest part of which is transverse, though irregular and waving. There are likewise some longitudinal ones which intersect the others; but at the pylorus they all become longitudinal, and terminate there.

At the superior orifice of the stomach, these rugæ are in a manner radiated, and seem to be a continuation of the plicæ or folds of the œsophagus; only they are thicker; and where these rugæ and plicæ meet, they form a sort of crown, which distinguishes the superior orifice of the stomach from the inferior extremity of the œsophagus.

In the interstices of these rugæ, there is often found a sort of slimy mucus, with which the whole cavity of the stomach seems likewise to be moistened. This mucus, which is termed *succus gastricus* or *stomachicus*, is much more fluid in living than in dead bodies, and has been supposed by Winslow, Leber, &c. to be supplied by small glands situated in the substance of the stomach. But Morgagni and Haller have seldom seen such an appearance; and Sabatier observes, that when such an appearance is met with, it may be considered as the effect of disease, and that nothing is more doubtful than the existence of glands in this place.

On the inner surface of the small extremity of the stomach, at the place where it ends in the intestinal canal, we observe a broad, thin, circular border, with a roundish hole in the middle. This hole is the inferior orifice of the stomach, called by the Greeks *pylorus*, which signifies a porter.

This border is a fold or duplicature of the two inner coats of the stomach, the nervosa and villosa; and it is formed in part by a fasciculus of fleshy fibres fixed in the duplicature of the tunica nervosa, and distinguished not only from the other fleshy fibres of the extremity of the stomach, but also from those of the intestines, by a thin, whitish circle, which appears even

through the external or common coat, round the union of the stomach and intestines.

The figure of the pylorus is that of a ring, transversely flattened; the inner edge of which, or that next the centre, is turned obliquely toward the intestines. This inner edge runs naturally more or less into little plaits or gathers, like the mouth of a purse almost shut; all which particulars are very different from what figures and dried preparations would make us believe. It is therefore a kind of sphincter, which can contract the inferior orifice of the stomach, but seems not capable of shutting it quite close.

Arteries of the stomach. The principal arteries of the stomach are the coronaria sinistra, which goes first to the cardia, and from this runs along the small curvature; coronaria dextra, which runs from the arteria hepatica to the right end of the small curvature, and joins the coronaria sinistra; gastro-epiploëca dextra, which arises from the arteria hepatica, and runs along the great curvature; arteria gastro-epiploëca sinistra and vasa brevia, which arise from the arteria splenica, and run along the left end of the great curvature.

These two arterial arches send a great number of branches toward each other on both sides of the stomach; and these branches are gradually ramified in different directions, by very different divisions and subdivisions; the greatest part of which communicate with those from the other artery.

From these frequent ramifications and communications of the arterial arches of the stomach, two different reticular textures arise; whereof one, which is the largest, lies between the common and muscular coats in the cellular substance found there: the other, which is very fine, lies on the surface of the tunica nervosa. This latter is a production of the first, being formed by means of a great number of very short rami, which go out from the other, and pass through the small interstices between the fibres of the muscular coat.

By

By artificial injections we can show a third extremely fine reticular texture of capillary vessels, which run between the glandular bodies and papillæ of the tunica villosa. These do not seem in the natural state to be purely blood-vessels, as inflammations and injections may incline us to think.

The arteries of the stomach come originally from cæliaca, by means of the hepatica, splenica, and coronaria. The pylorica and mesenterica superior likewise contribute to them by communications, more or less immediate. They communicate also with the mammariæ internæ, and diaphragmaticæ, and, by means of the epigastrica sinistra, with the mesenterica inferior.

Veins of the stomach. The veins of the stomach are ramifications of the vena portæ in general; and in particular of the meseraica major, splenica, and mesenterica inferior; the distribution of which may be seen in the description of the veins. They accompany the arteries more or less, and form nearly the same kinds of arches and reticular textures; with this difference, that they are proportionably greater, their reticular areolæ larger, and their external communications more frequent.

Nerves of the stomach. Between the common and muscular coats of the stomach, we find a great number of nerves of different sizes. Many of them accompany each other, in form of a broad flat fasciculus, along the small curvature of the stomach, from the superior to the inferior orifice. The rest are spread in different directions, on the sides, extremities, and great curvature, forming at different distances a kind of reticular plexus, from which a great number of filaments are detached to the inner coats.

They arise chiefly from the nervi sympathetici medii, or eighth pair, by means of the plexus coronarius stomachicus formed round the superior orifice of the stomach, by the expansion of the extremities of two

large ropes, which run down upon the œsophagus, by the name of *nervi stomachici*. The great sympathetic nerve, commonly called *intercostalis*, contributes likewise to them, by communicating filaments, which the plexus stomachicus receives from the semilunar ganglions of the plexus hepaticus, and particularly from the plexus splenicus. See Walter's beautiful and accurate Tables of the Nerves, of the Thorax, and Abdomen.

Uses of the stomach. The stomach receives in general whatever the mouth and tongue send thither thro' the canal of the œsophagus: but its particular use is to receive the aliments; to contain them for a longer or shorter time, in proportion as they are more solid or fluid; and to digest them, that is, to put them in a condition to be turned into that nutritious fluid called *chyle*.

This operation, which goes by the general name of *digestion*, and by which chylication begins, is performed partly by the *succus gastricus*, which flows continually from the *tunica villosa*, and partly by the continual contraction and relaxation of the muscular coat. These motions in men are but very weak, and nowise sufficient for digestion, without the assistance of the alternate motions of the diaphragm and muscles of the abdomen.

The pylorus, or fleshy circle of the inferior orifice of the stomach, serves to retain the aliments in it, till they have acquired a sufficient degree of fluidity, to pass easily through that opening. But by a particular irritation of the muscular coat of the stomach, and still more by a violent contraction of the diaphragm and muscles of the abdomen, the contents of the stomach may be very soon forced towards the small extremity, and pushed through the pylorus.

The gentle and alternate motions of the orbicular fibres of the muscular coat may assist in sending thro' the pylorus, in the natural way, the aliment that is sufficiently digested. This was called the *peristaltic* or *vermicular*

vermicular motion, by those who believed that it is successively reiterated, like that of earth-worms when they creep.

Trituration might be a proper enough term for this operation, provided it be made to signify only a gentle agitation or action of the fleshy fibres in a substance continually moistened by the gastric liquor, and not a violent grinding of a dry substance.

The situation of the stomach, which is nearly transverse, is likewise of use in making the aliment remain long enough in that cavity; and may serve to make the length of this stay, in some measure, arbitrary, by means of the different postures of the body; for when we lie on the left side, the aliment must remain longer than when we lie on the right, &c.

The obliquity of the stomach may serve to clear up a difficulty that very much torments those who believe that both orifices of the stomach lie on the same level; which is, how any heavy substance, once got into the stomach, can ever rise again to this level, to pass into the intestines.

§ 3. *The Intestines in general.*

Situation, size, and division of the intestines. Between the pylorus and the very lowest part of the abdomen lies a long canal, bent in a great many different directions by numerous convolutions or turnings, called the *intestines*.

This canal, thus folded and turned, forms a considerable bulk, which fills the greatest part of the cavity of the abdomen; and it is connected through its whole extent to membranous productions or continuations of the peritonæum, principally to those called the *mesentery* and *mesocolon*; of which hereafter.

The incurvations of the intestinal canal form two arches; a small one, by which it is connected to the *mesentery* and *mesocolon*; and a great one on the opposite

opposite side, which lies loose. The whole canal is generally about six or seven times as long as the subject.

The intestinal canal is neither of an equal size nor thickness through its whole length; from whence anatomists have taken occasion to consider its different portions as so many particular intestines, and to divide them all into small and great.

And as they still found some differences in each class taken altogether, they divided each into three portions, which they distinguished by particular names. In the small intestines, the three portions are named *duodenum*, *jejunum*, and *ileum*; and in the great intestines, *cæcum*, *colon*, and *rectum*.

Structure of the intestines. The intestines in general are composed of several coats, much in the same manner with the stomach. The first and outermost is a continuation of the mesentery, or of some other elongation or duplicature of the peritonæum.

This is commonly termed the *common coat*; and it has a cellular substance on its inner surface, like that of the stomach, which M. Ruysch thought fit to call a distinct coat by the name of *tunica cellulosa*.

The second coat of the intestines is fleshy or muscular, and made up of two planes; one external, the other internal. The external plane is very thin, and its fibres longitudinal; the internal plane is thicker, and its fibres run transversely round the circumference of the intestinal cylinder.

It would appear that these fibres are neither spiral, nor are they formed perfect circles or of rings; but they seem rather to be segments of circles, disposed much in the same manner as in the stomach, and thus surrounding entirely the intestinal canal.

These two planes adhere closely together, and are separated with great difficulty. They adhere likewise to the common coat by the intervention of the cellular substance,

substance, which is in greater quantities on the side next the mesentery than on the other.

The third coat is called *nervosa*, and is something like that of the stomach. It has a particular plane, which serves as a basis to sustain it, made up of very fine strong, oblique fibres, which seem to be of the ligamentary or tendinous kind.

To see this plane distinctly, a portion of the intestines must be inflated, the common coat removed, and the fleshy fibres scraped off.

This coat sustains two reticular substances, which are both vascular, one arterial, the other venal, accompanied by a great number of nervous filaments. These vessels and nerves are productions of the mesenteric vessels and nerves; and as they surround the whole canal of the intestines, some anatomists have formed them into a distinct coat by the name of *tunica vasculosa*.

The nervous coat sends off from its inner surface a great number of portions of septa, more or less circular, which contribute to the formation of what are called *valvulae conniventes*; of which hereafter. It likewise seems to sustain several different glandular bodies, which we discover in the cavity of the intestines.

The fourth or innermost coat is very soft, and is named *tunica villosa*. It has the same extent with the third coat, which supports it; and it lines all the septa of that third coat; but it is not uniform through the whole canal, as we shall show in the particular description.

It is now generally believed, that the fourth coat is a continuation of that in the stomach, and, of consequence, from the epidermis.

Intestina tenuia. The small intestines form one continued uniform canal; and although three portions of it have three different names, yet we have no sufficient marks whereby to distinguish them, to fix the precise extent

extent or length of each portion, or to settle its just limits.

The first and smallest portion of the whole canal is called *duodenum*; the second, which is much longer, *jejunum*; and the third, which is still longer than the second, *ileum*.

§ 4. *Intestinum Duodenum.*

THE first portion of the small intestines was called *duodenum*, from the length ascribed to it by the ancients, viz. the breadth of twelve fingers; and the moderns need not cavil much about this length, if it is measured with the ends of the fingers of the subject.

This intestine having arisen from the pylorus, is immediately bent a little backward and obliquely downward; then it bends a second time toward the right kidney, to which it is a little connected; and from thence passes before the renal artery and vein, ascending insensibly from right to left, till it gets before the aorta and last vertebræ of the back. It continues its course obliquely forward by a gentle turn, which may be reckoned a third incurvation, and also the extremity of the duodenum.

Through this whole course the duodenum is firmly bound down by folds of the peritonæum, especially by a transverse duplicature which gives origin to the mesocolon. The two laminæ of this duplicature being at first separate, and soon afterwards uniting, must leave a triangular space between them, which is lined with a cellular substance.

It is in this space that the duodenum adheres by means of the cellular substance to the parts already named; and the intestine is contained therein, as in a case; so that, without dissection, we can see nothing but its two extremities; and even these are hid by the colon, and by the first convolutions of the jejunum.

Structure

Structure of the duodenum. The first coat of the duodenum is consequently different from that of the other small intestines, having this peculiar to it, that it does not invest the whole circumference of the intestine; because, through the greatest part of its length, it lies in the triangular space already mentioned; and, for the same reason, there is a greater quantity of cellular substance belongs to the outer coat of the duodenum than to that of the other intestines.

The muscular coat of the duodenum is thicker than in the jejunum and ileum.

The tunica nervosa and villosa form conjointly, on the insides of this intestine, a great number of small duplicatures, which advance into the cavity more or less directly, like portions of circular planes, with one edge fixed to the intestine, and the other loose. These are what anatomists call *valvulae conniventes*.

The loose or floating edge of these valves is formed into small gathers or waves in the natural state. The whole surface of these duplicatures or valves is villous, as well as that of the intestines between them.

The villi of this intestine are thicker than in the stomach; but the texture of them in man is not like hairs, as they are commonly represented in figures, but rather like that of a fungous, granulated substance, composed of an infinite number of very fine papillæ of different figures; in which we see, through a microscope, a multitude of depressed points or pores, by which their whole surface seems to be pierced.

By the same help we observe, on different places of the inner surface of this intestine, several round villous tubercles, rising like small verrucæ at different distances from each other.

This substance sustains an infinite number of capillary vessels of different kinds; for besides the blood-vessels, we sometimes observe a great number of white filaments which run through it, and end at its inner surface like so many capillary roots of the vessels called

venæ

venæ lacteæ. When the villous substance is examined in the microscope, besides the blood-vessels, numerous follicles are observed lodged in cellular substance. These have been considered as the origin of the lacteal vessels, and have been called *ampullæ of Leiberkuhn*, because he first discovered them.

The fungous substance which binds these capillary filaments together, and surrounds them, is very tender; and the capillary extremities of the small blood-vessels distributed through it, seem to be turned toward the pores of the papillæ. Through these pores a mucous fluid, more or less transparent, is discharged, which continually moistens the cavity of the intestine.

Glands of the duodenum. The internal surface of the duodenum is furnished with a great number of small flat glandular tubercles, named after Brunner, which are raised on the sides, and depressed in the middle by a kind of fossula; and they are more numerous near the beginning of this intestine than any where else. About the pylorus they lie in a manner in heaps or clusters; and from thence the distance between them increases gradually all the way to the other extremity where they are single.

These glands, when examined carefully, appear like little bladders, with the orifices turned toward the cavity of the intestine, and the bodies fixed in the spongy substance next the nervous coat. They furnish a particular fluid, which is often found to be viscid.

The biliary orifice of the duodenum. In the inner surface of the duodenum, almost at the lower part of the first incurvation, and on the shortest side, there is a longitudinal eminence; in the point or apex of which lies a particular opening, which is the orifice of the ductus bilarius, within which the ductus pancreaticus likewise opens.

This intestine is commonly the widest, though the shortest, of the intestina tenuia, and has been called
by

by some *ventriculus succenturiatus*; and is invested by more cellular substances, especially while within its triangular case, where it wants the outer coat which the others have; and consequently it is more easily dilatable by the substances which might otherwise stick within it.

§ 5. *Intestinum Jejunum.*

Situation and size of the jejunum. The jejunum, so called, because it is oftener found empty than the ileum, begins at the last incurvation of the duodenum, and is there connected to the beginning of the mesocolon.

From thence it bends downward from left to right, and obliquely forward, or from the vertebræ, and makes several convolutions, which lie chiefly in the upper part of the umbilical region. Through all this course it is connected to the mesentery, in the manner that shall be explained hereafter.

It is a pretty difficult matter to fix the exact bounds between this intestine and the ileum. The external marks of a redder colour in the one than in the other, though pretty common, are not constant; and the internal marks fixed from the plurality of *valvulæ conniventes* are indeterminate, and oftentimes appear only from dissection.

These two intestines may be better distinguished by their different situations, which are pretty regular; but as even this mark is not particular enough, the most easy way that I have been able to contrive, and which will in most cases be found sufficiently exact, is to divide both intestines into five parts; and to allow nearly two-fifths to the jejunum, and three-fifths and a little more to the ileum.

Structure of the jejunum. The coats of the jejunum are nearly of the same structure with those of the duodenum, but thinner. The common coat is a continuation

uation of the mesentery ; and the cellular substance is in less quantity than in the duodenum, and indeed seems to be altogether wanting along the great curvature of the convolutions, where the longitudinal fibres of the muscular coat adhere very closely to the external membrane.

This muscular coat is not so strong as that of the duodenum. The longitudinal plane of fibres is very thin, and almost imperceptible, except along the great curvature, opposite to the connection of the mesentery, where we see, through the membranous coat, a kind of whitish ligamentary band, about the third part of an inch in breadth, which is continued along the great curvature of all the convolutions of this intestine, and of the ileum.

This ligamentary band is like those which we observe on the sides of the small extremity of the stomach. It adheres perfectly to the membranous coat, and to the longitudinal fibres of the muscular, which are here more visible, and appear to be stronger than in any other place.

The tunica nervosa, which we choose rather to call *reticularis*, and its proper cellular or lanuginous substance, have nothing peculiar to them more than has been already said about the intestines in general. By blowing artfully into this substance, it may be made to swell so much, round the whole cavity of the intestines, as to destroy all the duplicatures or *valvulae conniventes*.

These valves in this intestine are very broad, very numerous, and very near each other. On the side of the great curvature, their circumference is continuous and uniform ; but next the small curvature, there are several breaks in them, the extremities of some advancing beyond the rest, and terminating in points. Some of these valves go quite round, others only some part of the way ; and some of them are very small, which go obliquely

obliquely between two large ones, forming a kind of communication.

The papillæ of the tunica villosa are here more raised, more loose and floating, than in the duodenum; and each of them seems to be divided into several others, by incisures of a very singular kind. In other respects they agree pretty much with what was said in the description of the intestines in general. The observations and figures published by M. Helvetius, first physician to the French queen, in the Memoirs of the Royal Academy, express these papillæ, and the whole tunica reticularis, very justly.

The glandular lacunæ of the jejunum are of the same structure with the glandulæ Brunneri or duodenales; but they are disposed in a different manner. They are partly single, at different distances from each other; and partly in several clusters, like flat oblong bunches of grapes, called *plexus glandulosi Peyeri*. These are in the largest quantity near the great curvature, and they cross through several valvulæ conniventes at once.

The vessels, nerves, connections, &c. must be referred till the mesentery has been described.

§ 6. *Intestinum Ileum.*

Situation of the ileum. The convolutions of this intestine surround those of the jejunum on the two lateral and lower sides; and it passes in a winding course from the left side, by the hypogastrium, to the right side, where it terminates a little below the right kidney, joining the intestina crassa, in the manner that we shall relate hereafter. The lateral convolutions are supported by the ossa ilium, so called, not from this intestine, but from the region of the abdomen, termed *ilia*.

Structure of the ileum. The structure of the ileum is much the same with that of the jejunum; only the in-

ternal duplicatures or *valvulae conniventes* decrease gradually both in number and size. Near the extremity of the ileum their direction is changed; and instead of being transverse or circular, they become longitudinal, and terminate in a kind of pylorus, which advances into the cavity of the great intestines, as we shall see presently.

We observe likewise in this intestine, as in the jejunum, single or solitary glands or *lacunæ*, and also reticular glands or glands in clusters; the last of which, at the extremity of this intestine, is oftentimes of a great extent: but the greatest part of these glands appear to be flatter here than in the jejunum. The cellular substance of the external coat is in less quantities than in the foregoing intestines; and the ileum appears commonly more pale, or not so red as the jejunum.

Sometimes, though rarely, we meet with processes sent off from the jejunum or ileum, and of the same structure with these intestines. Their form, being similar to that of the finger of a glove, appears to have given them the name of *appendices digitales*. They are mentioned by different anatomists, and have sometimes been found to form true *herniæ*.

The vessels, nerves, connections, &c. must be referred to the history of the mesentery.

§ 7. *The Intestina Crassa in general.*

THE great intestines are one continued canal, divided into three portions, like the small ones. This canal begins by a kind of sacculus or bag, which is reckoned the first of the three portions, and called *cæcum*. The second portion, called *colon*, is the longest of the three; and is distinguished from them by a great number of particular eminences or convexities, which appear on its outer surface through its whole length. The last portion is named *rectum*; being more uniform,

form, narrower, thicker, and much shorter, than the colon.

The structure of the great intestines is nearly the same with that of the small ones, in regard both to the number and disposition of their coats. They are shorter, and have fewer convolutions, but are much more capacious. The coats in general are stronger, but especially the muscular coat. The villi and mucilaginous glands are different; and there are several other things relating to them, which will come in better in the particular history.

Situation and structure of the cæcum. The intestinum cæcum is only a round short broad bag, the bottom of which is turned downward, and the mouth or opening upward. It lies under the right kidney, and is hid by the last convolution of the ileum. It has nothing to distinguish it from the colon, excepting that it is a little wider, is shut at its under end, and gives origin to the *appendicula vermiformis*.

Appendicula vermiformis. On one side of the bottom of the cæcum lies an appendix, resembling a small intestine, nearly of the same length with the cæcum, but very slender. It is termed *appendicula vermiformis*, from its supposed resemblance to an earth-worm. Its common diameter is not above a quarter of an inch. By one extremity it opens laterally and a little obliquely into the bottom of the cæcum; and the other extremity is closed, being sometimes greater sometimes smaller than the rest of the appendix.

It has some contortions, like those of a worm when it is touched, from whence comes the epithet of *vermicularis* or *vermiformis*. Its structure resembles nearly that of the other intestines.

The internal coat of this appendix is folliculous, like that of the duodenum; and it is likewise reticular, the meshes being the glandular lacunæ, which continually discharge a fluid into its cavity.

It has been often disputed whether this appendix, or
the

the large portion, which is, as it were, the head of the colon, ought to be called the *cæcum*; but the general division of the intestines into great and small, leaves no room to doubt of its being only an appendix in man, whatever reason there may be for talking differently with respect to brutes and birds.

Through the membranous or common coat of the *cæcum*, we see three white muscular ligamentous looking bands, which adhere very closely both to the outer and muscular coat. One of them is hid by the adhesion of the mesocolon; and all the three divide the *cæcum* longitudinally into three parts more or less equal.

They all unite on the *appendicula vermiformis*, and cover its whole outer side immediately under the common coat. Though they appear exteriorly on the *cæcum* to be ligamentary, they are made up interiorly of fleshy fibres which accompany and strengthen the longitudinal fibres of the muscular coat.

The villous substance of the inner coat of the *cæcum* is very short, and furnished in several places with glandular lacunæ or solitary glands, broader than those of the small intestines.

These glandular lacunæ or folliculi are flattened and depressed in the middle like small-pox. When we blow through a pipe into these lacunæ without touching them, the folliculi are inflated, and represent little caps with a hole in the middle of their convex side.

§ 8. *Intestinum Colon.*

Situation and structure of the colon. The colon is the most considerable of all the intestines. From the *cæcum*, of which it is a continuation, it reaches, in form of an arch, above the umbilical region, and to the lower part of the left hypochondrium. Its continuity is, however, a little interrupted by the ileum, which advances into the cavity of the colon, and, together with a certain

certain fold of that intestine, forms what is called *valvula coli*.

The whole convex side of the colon is divided longitudinally into three parts, by three muscular bands, first known to Sylvius and Eustachius, continued from those of the cæcum, and of the same structure with these. Two of these bands run on each side along the great curvature of the colon; and the third along the small curvature.

The uppermost band of the two that belong to the great curvature, is the broadest of the three; that which belongs to the small curvature is the narrowest, and lay hid by the connection of the mesocolon, till it was brought to light by M. Morgagni.

These three longitudinal bands do the office of longitudinal fræna, between which this intestine is thro' its whole length alternately depressed into transverse folds, and raised into considerable eminences. All the folds are duplicatures, which form portions of *valvulæ conniventes* in the cavity of the intestine; and the eminences form receptacles, called the *cells of the colon*.

All the coats of the colon concur equally to the formation of these duplicatures and cells, the depth of which decreases gradually toward the extremity of the intestine, and neither of them go any further than the ligamentary bands.

These portions of the colon which are immediately covered by the ligamentary bands, are smooth and without rugæ; and therefore, if these bands alone are cut across, the intestine is not elongated sufficiently to destroy all the folds and cells.

The common coat on one side is a continuation of the mesocolon, and on the other side it contributes, by the same continuation, to form the omentum. The longitudinal fibres of the muscular coat are very slender; excepting in the bands already mentioned; and those which answer to the annular or circular fibres of the small intestines, are only segments stretched over the eminences and folds. The other coats are nearly as

in the cæcum; only the glandular lacunæ or solitary glands are broader and more numerous.

The arch of the colon begins under the right kidney, near the haunch. It runs up on the fore-side of that kidney to which it is connected; passes under the vesicula fellis, which tinges it with a yellow colour at that place; and continues its course before the first incurvation of the duodenum, to which it adheres, and partly hides it. In this part of its course, therefore, there is a remarkable connection between the colon, duodenum, right kidney, and vesicula fellis.

From thence the arch of the colon runs before the great convexity of the stomach, and sometimes a little lower; then turns backward under the spleen, in the left hypochondrium; runs down on the fore-side of the left kidney, to which it is connected; below this kidney, turns toward the vertebræ, and terminates there by a double incurvature, or by two opposite convolutions, which represent in some measure an inverted Roman S.

These last convolutions of the colon are sometimes multiplied, and even advance to the right side of the pelvis; and along the great arch, and the two last incurvations, there are a kind of fringes, called *appendices coli adiposæ*, which we shall afterwards explain, as also the connections of the colon with the mesocolon and omentum.

Valvula coli. At the place where the cæcum joins the colon, one portion of the circumference of both is depressed, and forms a large fold on the inside, which advances into the cavity of the intestine, and gets the name of *valve* of the *ileum*, of the *cæcum*, or of the *colon*. Some have named it after Bauhin, who was said to discover it accidentally at Paris in 1579, by throwing water into the intestines, and finding that the passage was obstructed at the end of the ileum; but Vidus Vidius has described it several years before this. It is a little open in the middle, and its extremities are very thick,

thick, by reason of the mutual duplicature of the coats of the cæcum and colon.

The extremity of the ileum is as it were grafted in the opening of this fold, and strongly united to its sides by the adhesion of its transverse fibres to the transverse fibres of the cæcum and colon.

This union forms a pretty thick ring, which likewise advances into the common cavity of the cæcum and colon, where it is wrinkled or formed into gathers, almost like the lower extremity of the œsophagus, the pylorus, or inside of the anus. Its circumference is more or less oval; and, by a kind of continuity with the common fold of the cæcum and colon, it forms two productions, which M. Morgagni calls the *retinacula valvulæ Baubini*.

The membranous coat of the extremity of the ileum is continued on the cæcum and colon, without sinking into any fold at the place where the ileum enters the colon. The longitudinal fibres of the muscular coat seem here to be confounded with the nearest circular fibres of the cæcum and colon.

The inner portion of the muscular coat of the ileum runs in between the circular fibres of the ileum and colon, as into a common fold of these two intestines; from all which a pretty thick short portion of a fleshy tube is formed, which is the circular rising already mentioned.

The tunica nervosa and villosa of the extremity of the ileum likewise enter the common cavity of the cæcum and colon, and on the edge of the circular rising join the like coats of these two intestines; so that the circular rising or short muscular tube is covered both on the outer and inner sides by a nervous and villous coat; that on the inside being supplied by the ileum, and the other by the two great intestines.

The situation of this extremity of the ileum is most commonly transverse, and is inserted almost in the same direction in the common cavity of the two intestines al-

ready mentioned; but it is often a little more inclined toward the cæcum than to the colon; and whereas in all other places the ileum is wide and easily dilatable, it is very narrow at its insertion, and its sides are more solid and firm.

It is chiefly in this structure that the mechanism of the insertion of the ileum in the cæcum and colon consists; about which insertion or opening, authors are very much divided, some reckoning it a valve, others only a sphincter.

It is very evident, from what we have said, that it is a double machine contrived to hinder the return of the excrements into the ileum, because it can produce this effect partly as a valve, and partly as a kind of sphincter. The dried preparations of this part give a very false idea of its structure and conformation; and the same thing is to be said of the opening of the appendicula vermiformis into the cæcum.

The capacious arch of the colon is connected by both extremities to the regio lumbaris, near the kidneys, by two particular ligaments, one on the right side, the other on the left, which are only small duplicatures of the peritoneum, more or less transverse.

The remaining portion, which forms the two convolutions in form of the Roman S, contracts below the left kidney, being narrower there than lower down. The coats of this portion become gradually thicker and stronger, and likewise the ligamentary bands, which approach each other by degrees, and seem to increase in breadth.

The vessels, nerves, &c. will be found in the description of the mesentery.

§ 9. *Intestinum rectum, and Anus.*

Situation, figure, and size of the rectum. The last of all the intestines is named *rectum*, or the *straight gut*, from its situation; for, when viewed directly forward,
it

it appears to run down in a straight course from the last vertebra of the loins, on the foreside of the os sacrum, all the way to the os coccygis, where it ends in what is called the *anus*.

This intestine, properly speaking, is a true continuation of the last convolution of the colon; and it is the repository, sink, and common sewer of the whole intestinal canal. It has likewise a special relation to the bladder, and to the parts of generation in both sexes.

The rectum having passed below the last vertebra of the loins, to the inside of the os sacrum, is bent backward, on that concave side, to which it is connected, in the manner that shall be afterwards explained; and having reached the os coccygis, it runs likewise in the direction of that bone, and bends a little forward, terminating beyond the extremity of the coccyx.

The figure of this intestine varies according as it is full or empty. When empty, it is irregularly cylindrical, and sinks in by a kind of transverse folds; and in that state, it is about three fingers breadth in diameter more or less. When full, it is wider in proportion to the quantity of fæces, wind, or whatever else is contained in it; and it may be extended to the size of a large bladder, so as to represent a kind of stomach.

Structure of the rectum. The membranous coat often contains a great quantity of fat, spread between it and the muscular coat, and forming round the intestine numerous eminences, in the room of the appendices adiposæ of the colon, which shall be explained in the history of the omentum.

The muscular or fleshy coat is very thick; and the longitudinal fibres, which in the other intestines are very thin, are in this stronger than the circular fibres of the rest. The ligamentary bands continue to increase in breadth, and to approach each other, as has been said; and it is to the fleshy fibres of these bands that the thickness of the longitudinal fibres seems to be owing.

The

The nervous or filamentous and internal coats, are larger here than in the other intestines; and when the rectum is empty, they form a great number of waving rugæ in its cavity, which disappear in proportion as that cavity is filled.

The innermost coat is very improperly termed *villosa*, and scarce deserves the name of *papillaris*, because of the smallness of the little corpuscles spread on its surface. It contains a great number of single or solitary glands; and it is always moistened by a mucus of different consistences, discharged by these glands or folliculi, and perhaps by the corpuscles also.

Near the extremity of this intestine the rugæ or folds become in a manner longitudinal; and at last, towards the circumference of the inner margin of the anus, they form little bags or semilunar lacunæ, the openings of which are turned upward, toward the cavity of the intestine. These lacunæ are something like those of the lower extremity of the œsophagus, or upper orifice of the stomach.

Muscles of the anus. At length the extremity of the rectum contracts, and terminates by a narrow orifice called the *anus*, the sides of which are disposed in close folds or gathers. This extremity of the intestine has several muscles belonging to it, some of which surround it like sphincters; the rest are broad fleshy planes inserted in it, and which, being likewise fixed to other parts, sustain it in its natural situation, and restore it to that situation after being disturbed by the force necessary for the exclusion of the fæces. These latter muscles are termed *levatores ani*; the first go by the general name of *sphincters*. See Description of Muscles in Vol. I.

§ 10. *Mesenterium et Mesocolon.*

Division of the mesentery, &c. This great bundle of intestines is not left to move at random in the cavity of the abdomen; but artfully bound down by a membra-

nous web, which prevents the intestinal convolutions from being intangled in each other, and from being twisted or compressed in all their different ways of meeting; and yet allows them a gentle floating, but limited motion.

This web goes still by the ancient Greek name of *mesentery*, as being in some measure in the middle of the intestines. It is distinguished into two portions; one of which being very broad and very much plaited, connects the small intestines; the other, which is long and incurvated, does the same office to the great intestines.

These two portions are in reality only one and the same continuation of the membranous lamina of the peritonæum doubled back upon itself, and they are distinguished only by their breadth. Taken both together, they form a kind of spiral roll, more or less plaited in its circumference. The first portion has retained the name of *mesentery*, the other is termed *mesocolon*.

Structure of the mesentery, &c. The mesentery begins at the last incurvation of the duodenum, and runs obliquely from left to right, along the vertebræ of the loins. In this space, the membranous portion of the peritonæum is detached on both hands, produces a duplicature by two elongations or particular laminæ applied to each other, and thus forms the mesentery.

It is narrower at its upper and lower parts, but chiefly at the upper. The middle portion is very broad, and the edge of it next the intestines is every where very much plaited. These plaits or folds are only waving inflexions, such as may be observed in the edge of a piece of shamoy which has been often drawn thro' the fingers. They make this edge of the mesentery very long, and they run through about one third of its breadth.

The two laminæ are joined together by a cellular substance, which contains glands, vessels, and nerves, that

that shall be described hereafter; and in some subjects it has a great quantity of fat, which keeps the two laminæ at a good distance from each other.

Along the whole circumference of the mesentery, the two laminæ are naturally separated, and applied to the two sides of the small intestines, which they invest by their union or rather reciprocal continuation on the great curvature of that canal, and carry it as in a scarf or sling. This is what forms the external or membranous coat of the intestines.

The mesocolon is the continuation of the mesentery; which having reached the extremity of the ileum, contracts and changes its name. At this place, the particular lamina which is turned to the right side, forms a small transverse fold, called *ligamentum coli dextrum*.

Afterwards the mesocolon ascends toward the right kidney, where it seems to be lost by the immediate adhesion of the colon to that kidney, and to the first incurvation of the duodenum. Then it appears again, and increasing in breadth, it continues its course almost transversely under the liver, stomach, and spleen, where it begins to turn downward, under the left hypochondrium, toward the kidney on the same side.

Through this whole course the mesocolon extends in breadth, and forms nearly a transverse semicircular plane, very little plaited at its great circumference. By this circumference or edge, it is connected to the colon, and hides that ligamentary band of this intestine, which runs along its small curvature. By its short or small edge, it forms the triangular case of the duodenum; and, by its great edge, the external coat of the colon, in the same manner as the mesentery does that of the small intestines. As it passes under the large extremity of the stomach, it adheres a little to the lower portion of that extremity, as the diaphragm does to the upper.

Having got below the left kidney, it contracts, and forms another transverse fold, called *ligamentum coli sinistrum*. Afterwards it expands again, but not so much

much as in the upper part ; and runs down on the left psoas muscle, toward the last vertebra of the loins, This descending portion is fixed to the convolutions of the colon, in the same manner as the superior portion is to the arch of that intestine.

The intestinum rectum is likewise invested by a particular production of the peritonæum, called commonly by the name of *meso-rectum*. This production is very narrow ; and about the middle of the foreside of the rectum, it forms a transverse semicircular fold, which appears when the intestine is empty, but is lost when it is filled.

Between the laminæ of the mesentery, a great number of glands lie scattered through the cellular substance. In the natural state, these glands are something of the figure of lentils or little round beans, some of them being orbicular, others oval, but all of them a little flattened, and in corpulent subjects we find them surrounded with fat.

These glands are of the number of those that anatomists call *glandulæ conglobatæ*, the structure of which is not as yet sufficiently known. They seem to be of a cellular substance, surrounded by a very fine membrane or coat, on which, by the help of microscopes, we discover an intertexture, of particular filaments, which Malpighi believed to be fleshy fibres.

The nicest anatomical injections have not hitherto given us any satisfaction about these particulars : for though they be made with all possible care, they always fill the folliculous texture of these glands ; and tho' by means of these injections we may discover a great many vessels, which were before invisible, we are not a whit the nearer our purpose, because we cannot by this method distinguish the secretory, excretory, and blood-vessels from each other.

Besides the blood-vessels, which are distributed in a reticular manner in the mesenteric glands, and besides many nervous filaments spread through them, we
discover

discover an infinite number of small vessels of another kind, running from gland to gland.

These vessels are extremely thin and transparent, and furnished on the inside with numerous valves, which appear on the outside like little small knots very near each other. They go out from each gland by ramifications, as by so many roots; and having formed a small trunk, they are again divided, and enter some neighbouring gland by the same kind of ramifications by which they went out from the former.

Lacteal vessels. These are termed *lymphatic vessels*, because for the most part they contain a very clear, limpid, though mucilaginous serum, called *lymph* by anatomists. But as they have likewise been observed to be filled with a white milky fluid, called *chyle*, they have been called *vasa chyliifera*, or *venæ lacteæ*. They have the name of *veins*, because their valves are disposed as those of the ordinary blood-veins, and because the fluid which they contain runs from smaller into larger tubes: But the particular description of these will come in more properly in a latter part of the work.

§ 12. *The Blood-vessels and Nerves of the Intestines.*

Blood-vessels of the intestines. The duodenum has commonly a particular artery called *duodenalis* or *intestinalis*, which comes indifferently from the *stomachica coronaria*, *pylorica*, *gastrica major*, or *hepatica*. It has likewise several distinct ramifications from these trunks, and from the *mesenterica superior* and *splenica*; which ramifications communicate with each other.

The *arteria duodenalis*, and the other additional small arteries, form a vascular net-work round the muscular coat of the intestine, which sends out a great number of capillaries toward both the outer and inner sides, that make the whole intestine look of a red colour.

The veins of the duodenum are *ramæ* of the *vena portæ*

portæ, and the distribution and denomination thereof is pretty much the same with that of the arteries; only they communicate more with each other than the arteries, and also with the great hæmorrhoidal vein.

The venal ramifications form round the duodenum a net-work like that of the arteries; and the same kind of vascular texture is more or less to be found in all the other intestines.

The arteries of the jejunum come chiefly from the mesenterica superior, and some from the ascending branch of the mesenterica inferior. The veins for the most part open into the great meseraica; and the rest go into the splenica and small meseraica or hæmorrhoidalis interna.

The principal subaltern trunks of these arteries and veins accompany each other through the cellular substance between the laminæ of the mesentery; are distributed by branches and rami; and form the meshes, lozenges, and arches, which shall be mentioned in the description of the arteries and veins. The last of these arches and lozenges, or those next to the intestine, produce two small vascular planes, which separate from each other very distinctly, and surround the intestinal canal in a reticular manner.

The blood-vessels of the ileum have the same sources with those of the jejunum; and it ought to be observed concerning both these vessels, and those of the jejunum, that in their whole course through the mesentery, they give ramifications to the glands, laminæ, and cellular substance of the mesentery; and also that there is a kind of communication between several small meseraic veins and the capillary rami of the venæ lumbares and spermaticæ.

The arteries of the cæcum and appendicula vermiformis, are ramifications of the last branch from the convex side of the mesenterica superior; and they have likewise some small ones from the second and third branches, when both are found. The veins of
these

these two parts are ramifications of the great meseraica; and one of these rami is by Riolan termed *vena cæcalis*.

The straight portion of the arch of the colon, or that which is an immediate continuation of the cæcum, is supplied with arteries by the second branch that comes from the concave side of the mesenterica superior, and likewise a little by the third, when there is a third.

The superior or middle portion of the arch of the colon, is furnished by the first branch from the same side of the mesenterica superior, which by a bifurcation communicates on both hands with the other portions of the arch of the colon.

The left portion of this arch derives its arteries partly from the first branch of the same mesenterica, and partly from that of the mesenterica inferior; which two branches form the celebrated communication or common arch of the two mesentericæ.

By means of this communication or continuation, in case one artery should be obstructed or compressed, the other would furnish blood to all the branches below the place of the obstruction. The second branch of the mesenterica inferior gives likewise small arteries to the left extremity of the colon.

The descending convolutions of the colon, which represent a Roman S, are supplied by the other branches of the mesenterica inferior; the last of which forms the hæmorrhoidalis interna.

The veins of all these portions of the colon form trunks which terminate chiefly in the hæmorrhoidalis interna or mesaraica minor and major, and likewise in the vena portæ ventralis. The distribution of these branches and ramifications is in some measure the same with that of the arteries, as may be seen in the description of the veins.

The arteries of the rectum are furnished by the hæmorrhoidalis interna, the last branch of the mesenterica inferior, which communicates with the hypogastrica;
I
and

and particularly with the hæmorrhoidalis externa, a production of one of these arteries.

The veins of the rectum go to form the beginning of the mesenterica minor or hæmorrhoidalis interna; and they communicate with the hæmorrhoidales externæ, which are rami of one of the hypogastricæ. They communicate likewise with the capillary ramifications of the other hypogastric veins, which come from the internal parts of generation of both sexes.

It is here to be observed in general, that there is a successive continuation, more or less simple or multiplied, between all the arteries of the intestinal canal, and likewise between all the veins; and also that the veins are here thinner and more capacious than the arteries, in a greater proportion than in the other parts of the body.

Nerves of the intestines. The nerves of the duodenum are the middle plexus of the semilunar ganglion, and some filaments of the plexus stomachicus and hepaticus.

The nerves of the jejunum, ileum, and mesenteric glands, are the plexus mesentericus superior, the posterior mesenteric fasciculi, and the plexus mesentericus inferior.

The nerves of the cæcum are the posterior mesenteric fasciculi or plexus, and the plexus mesentericus inferior.

The nerves of the arch of the colon are the same fasciculi, and the two plexus mesenterici.

The nerves of the last convolutions of the colon are the posterior mesenteric fasciculi, and the plexus mesentericus inferior and sub-mesentericus.

The nerves of the rectum are the plexus mesentericus inferior, plexus sub-mesentericus or hypogastricus, and the two ganglions of that plexus.

The nerves of the anus, and of its muscles, are the ganglions of the plexus sub-mesentericus, the inferior

rope of both sympathetici maximi, and the common arch of the extremities of both ropes.

§ 12. *Digestion.*

WITHIN the human stomach we first meet with a great quantity of mucus, spread upon its villous lining; which mucus is not unfrequently tinged by some of the bile returning into the stomach. Besides this, in an empty stomach after fasting, upon bending the body, a great quantity of a limpid humour will arise into the mouth, altogether of the same nature with the saliva, but more mucous; which liquor is very rarely to be found pure or unmixed in the stomach. It is very far from possessing any acid acrimony, when it can be had pure from the food. Left to itself, it changes, both in man and brutes, rather to a lixivial or alkaline nature, when it is separated from the acid illuvies of the aliments, more especially in an hungry animal. This liquor distils from the arteries of the stomach, through its villous coat, after the manner we see by anatomical injections: by which water, fish-glue, and oil, may be easily urged into the vessels of the stomach, so as to sweat through its numberless pores.

The stomach then, contained within the abdomen, which is perfectly full, will from thence, as in a press, receive a force or compressure upon its sides, which lie betwixt the diaphragm; the concavity of whose right wing is filled by the liver, under which, and within the left wing, lies the stomach extended almost transversely behind the resisting muscles of the abdomen, viz. the recti and obliqui, but chiefly the transverse. The more the stomach is filled, the more it is urged by this pressure of the abdominal muscles; because, at the same time, it rises upward in a right angle to the contact of the peritonæum.

Now we must speak of what is received into the stomach, and why it is received. The Creator has given
to

man the two faithful guards of pleasure and pain for his preservation ; the one to avert evil, the other to invite him to useful actions. But the taking of aliment is an action very necessary and useful to our support. For since every day there is a great quantity wasted from the body, by a dissolution of its true substance thrown off by perspiration, a repairing of this loss is every way necessary, as the body is manifestly wasted by fasting. But this necessity of taking food recurs the more quickly from the nature of the blood itself, which is strongly inclined to a sharp, saline, lixivial quality, and to a putrid acrimonious state : to which last it is continually solicited, and approaches from the putrescent disposition of all the more stagnant humours of the animal, promoted by the incessant and natural motion of the heart and arteries, and by the heat, which very much promotes the putrefaction of all the animal humours. Moreover, the coagulable disposition of the blood, continually losing a great part of its diluting water by insensible perspiration, calls strenuously for a recruit of the watery element, in the way of drink, by which its cohesive globules are separated from each other, and hindered from running together into a consistent mass.

These truths are proved not only from their causes, but likewise by the appearances which they exhibit in men and other animals killed by hunger. For, in such, we commonly observe a sharp stinking breath, a looseness of the teeth from the dissolving acrimony of the juices, violent pains in the stomach, sharp fevers, and even a true madness. All these disorders arise sooner and stronger, as the person is more robust and more violently exercised with motion of body ; but they ensue very slowly in phlegmatic people, who are unactive, perspire little, and put the blood into no great motion. Lastly, those who have been without food, have also lived without bodily exercise, and for the most part laboured under a disease of the nerves.

The fresh chyle, composed, for the most part, out of the acescent class of vegetables, and of a consistence always thinner than that of the blood itself, being received into its torrent of circulation, temperates the putrescent acrimony, dilutes the coagulation threatened, and reduces the whole mass to that moderate degree of saline nature which is natural to man: and finally, the chyle, but more especially that derived from the flesh of animals, and likewise what is formed of farinaceous vegetables, being replenished with gelatinous lymph, serves to repair the consumption or waste which is made from the body itself, to the vacuities of whose broken solids it is applied by the causes which promote the growth of the body. The drink dilutes the cohesive or grumous inclination of the blood, hinders its putrefaction, and carries off by the emunctories such particles as are already putrid: and hence it is, that a person may live for a long time without solid food, if he is supplied with drink; but without drink, life subsists but a few days.

We are solicited to take food, as well from the sense of pain we call hunger, as from that of pleasure, which is received by the taste. The first of these proceeds doubtless from the sensible folds or wrinkles of the stomach rubbing against each other by the peristaltic motion, of which there is an acute sensation, joined with a pressure from the diaphragm and abdominal muscles, by which the naked villi of the nerves on one side grate against those of the other, after a manner intolerable. Thus we are effectually admonished of the dangers ensuing from too long abstinence or fasting, and excited to procure food or nourishment by labour and industry.

To this sense perhaps the gastric liquor or juice of the stomach, collected and sharpened after feeding, does in some measure conduce, unless it becomes putrescent.

Thirst is seated in the tongue, fauces, œsophagus, and stomach. For whenever these very sensible parts, which are constantly and naturally moistened by mucous and salival

salival juices, grow dry from a deficiency of those or the like humours, or are irritated by a redundancy of muriatic or alkalescent salts here lodged, there arises a sense much more intolerable than the former, as thirst is more dangerous; whose uneasy sense continues until the proportion of diluting water in the blood, being recruited, restores the necessary moisture and free secretion required in the parts before mentioned. From hence we learn, why thirst attends labour, which exhales a greater proportion of the watery perspiration; and why it is a symptom of fevers, where there is an obstruction of the exhaling vessels belonging to the tongue and fauces; why simple water is less efficacious in abating thirst, which yields nevertheless easily to some acid liquors, that not only moisten and render fluid, but also, by their mild irritation of the tongue and mouth, provoke forward the humours, and at the same time correct their putrid tendency.

From these causes, mortals, being under a necessity of seeking food for the support of life, have in all ages determined their choice to the succulent parts of vegetables and animals, in such a manner, that water and salt seem to be added only as third assistants. And first, it is probable, that the primitive choice of our foods was made by experiments, according as the variety of smells and flavours in vegetables and their several parts invited, and as the strength or recruit of our faculties thence following confirmed their utility. But by degrees, animals increasing so much as to be inconvenient to the husbandman, and vegetables alone not being sufficient for supporting them under their labours, the flesh of animals was afterwards added. At present, both the number and variety of substances are almost infinite, which we take either as food or seasoning for our nourishment.

Although there are many instances of particular persons, and even of whole nations, who have supported life only with one kind of food, either vegetable or animal,

or even from a small class of either of them; and lastly, though some have lived altogether upon milk or its whey; yet it seems to be necessary, both from the nature and fabric of the human body itself, as well as from certain experiments, that we ought to support life by the two kinds of food, so intermixed, that neither of them may exceed their reasonable bounds; and this mediocrity we are taught from the loathing itself, which follows to any one kind of food that has been continued for too long a time together.

The flesh of animals appears a necessary part of our nourishment, even from the fabric of the human stomach itself, resembling that of carnivorous animals; and from the two rows of teeth, with the canine teeth in each jaw; also from the smallness and shortness of the intestinum cæcum, and from the necessary vigour which we require. For the flesh of animals alone contain the gelatinous lymph ready prepared for the recruit both of our fluids and solids; which, being extracted from the broken vessels and fibres, easily passes in great abundance into the blood. An abstinence from animal food generally causes great weakness both to the body and stomach, being perpetually attended with a troublesome diarrhœa. But in the amplitude and length of the intestina crassa, man agrees with herbivorous animals.

Esculent vegetables are generally of the acescent kind; only some few of them are either alkalescent, or else replenished with a spicyness. But few of them have that animal glue which is spontaneously changeable into blood; for it is only the small portion of jelly which is drawn from their farinaceous parts, that, after many repeated circulations, is converted into the nature of our indigenous juices. Yet these are necessary to avoid over repletion with blood, and of too putrescent a kind from the use of animal food alone, which, from the most creditable accounts of the anthropophagi, prevails to so great a degree as to breed the hot
alkalescent

alkalescent scurvy, a fierce or savage temper, a stinking and leprosy of the body, with a lixivial corruption of all the juices; which are only to be cured by change of diet, in which a vegetable acidity abounds. Hence it is, that we are furnished but with few canine teeth; and that our appetite in health, but more especially in disease, is stronger for acidulous vegetables, in proportion to our warmer temperature of body, and greater heat of the country or the season of the year. Hence we see, that in the hottest climates, people live either altogether upon vegetables, or use flesh meats but very rarely, and not without danger of acute diseases; while, in the colder countries, flesh is eaten freely with less danger: and hence bread, or a farinaceous aliment similar to it, is made a standing part of our food throughout the world.

The best *drink* is afforded by pure water, not incorporated with salts, nor with air, which may excite fermentations. Of this kind we justly prefer that from a mountainous spring, which runs through a sandy bed, being very cold, clear, light, and insipid. Whenever we are unprovided with such pure water, as is frequently the case in the lower flat countries, or when any increase of the strength and muscular constriction of the stomach is required from a spicy stimulus, its place may be very well supplied by wine, prepared chiefly from grapes; but, in defect of those, from apples and pears; which, after a due fermentation, becomes clear, and is replenished with an acid salt, and oily or inflammable spirit, well diluted in water. Liquors of the same kind, replenished with a vinous or inflammable spirit, but more flatulent, heavy, and less palatable, are prepared from corns roasted, afterwards extracted with boiling water, and prepared by fermentation, as a substitute for wine in those countries where the grape does not ripen.

But mankind have invented various pickles and sauces, such as salt, vinegar, and acids of various kinds,

to correct the putrescent disposition of flesh-meats; with pepper, mustard, and other hot spices, to strengthen the action of the stomach, which is perpetually weakened by the use of vegetables: and to these add sugar, salt, and the eastern spices, which are generally added either for the sake of flavouring or preserving our food. But all these yield no nourishment, being destitute of all gelatinous lymph, or any farinaceous quality.

The aliments are variously prepared, according to the difference of country, climate, or season; and thus their crudity is removed, their solid fibres softened, their superfluous air expelled, and their disagreeable acrimony changed and rendered agreeable. But, even after this, many vegetable foods, and more especially flesh-meats, require to be divided, in some degree, by a previous triture in the mouth, which is particularly necessary in man, whose stomach is but little fleshy, and likewise that the food may not stay so long upon the stomach as to become putrid.

The measure of our food is determined by hunger, which is different according to the difference of bodies. Animal and farinaceous food nourishes most: other aliments ought to supply by their quantity what they want in their powers of nourishment. In general, we are nourished best by a somewhat spare diet, unless subjected to much labour.

Into this stomach, therefore, the aliments are let down, often almost crude, and but little chewed, of various kinds; some of them being alkalescent, as flesh-meats; rancescent, as oily or fat substances; or aciescent, as bread, milk, and most of the vegetable kind. These, we observe, are digested in a heat equal to that of an hatching egg, administered to the stomach by the contiguous spleen, liver, and heart; and this in a cavity altogether close or confined above, as it also is below, by the ascent of the incurvated pylorus, and in a great measure by a shutting valve, and likewise constricted by a muscular force of the fibres; from whence
we

we observe, that even milk itself is often retained in the stomach of strong animals several hours after a meal, without passing into the intestines. Observe, again, that these aliments are continually cohobated or moistened with watery juices, and at the same time are replenished with a good deal of air incorporated with them, either naturally or in the mastication. This air, therefore, expanding by the force of heat, putrefaction, or fermentation, breaks open the cells by which it was included, divides the viscid liquors, and softens or opens the solid fibres, so as to make a way for discharging their juices. But the same substance of the air, turning to a solid, makes the principal glue or cement by which the animal solids and other bodies receive their firmness; and this, being extricated by heat, leaves the other elementary parts friable, or without a vinculum, as we see from the change which happens in Papin's digester, in the stomachs of many animals, and even in that of ourselves. This air, set at liberty by the digestion, often distends the stomach more than the food itself, under the denomination of flatus. While this air is extricated, the aliments by long stay begin to corrupt or change into a nauseous liquid, often acescent; or otherwise putrescent, which however happens less in mankind from our use of bread and salt; or rancescent, as appears from the flatus and matters eructated, often of a most fetid, caustic, and inflammable nature, from substances of the like disposition. This putrescency, or imperfect putrefaction, says Haller, is almost the only cause of digestion in fish, serpents, and carnivorous birds. Hence, in mankind, metals themselves, by long stay in the stomach, grow soft, and are eroded; but from Spallanzani's experiments it appears, that there are no signs of putrefaction in the time of digestion, except in sick animals. (See Experiments on Digestion, &c.) At this time hunger is absent, the nervous plates of the stomach being removed and defended from their contacts with each other by the interposed aliment, at the same time that the juice of the stomach itself is less sharp and
freer

freer from a mixture with the old remains of the last food, which often excite a nauseating uneasiness in the nerves of the stomach.

But that the aliment might not degenerate into a complete acidity, there is a check from the putrescent degree of the heat, the power of the juices distilling from the stomach, and that of the saliva itself, swallowed to the amount of half an ounce in an hour, and rather inclined to an alkalescency: also these juices being ground together with the aliment, macerate, soften, and dissolve the fibres themselves and their cellular bands, leaving them a soft pulp like what we see by letting them stand for a long time in warm water, extract their juice, and mingle it with themselves. There is therefore no particular kind of ferment in the stomach; from which the design of nature, the disposition of the stomach, and its use, are all very remote. And yet the juice of the stomach alone, by its longer stay in fishes, dissolves the bones which they had devoured. (*See Spallanzani's Experiments.*)

For the fleshy fibres in the stomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themselves more powerfully than when the stomach is empty, and with a greater force in proportion as it is more full, the round swelling of which stretches these fibres. And, first, the muscular stratum, which passes along the lesser curvature, connects the pylorus with the œsophagus; and, being inserted only into the left face of the former, draws it to the right. The principal stratum of the circular fibres contracts the capacity of the stomach, according to its length; grinds or intermixes its contents together with the liquors; and determines them both, like the pressure of two hands placed opposite, to flow towards the pylorus: but this flux through the pylorus is not made continually on account of the valvula pylori, and likewise because this motion begins from some part that is more irritated; and from thence the aliment

ment is driven here upward, as in other parts downward. These alternate contractions at last terminate in a full evacuation. In this action of the stomach, there is nothing which resembles the triture made by the strong gizzards of granivorous fowls, which some anatomists have ascribed to the human stomach; which yet has a considerable degree of strength, since the contraction of its fibres is often more than a third part of their length; for we frequently see the stomach reduced to less than a third of its diameter: frequently also the stomach is observed to be diminished to much less than a third part, even to the breadth of an inch; which, lastly, makes it fit for moving forward sharp-pointed substances. Yet it neither bruises berries nor the softest worms.

But that motion which it receives from the diaphragm and muscles of the abdomen, is stronger than the peristaltic force of the stomach; for, by this, the stomach is more perfectly emptied by a close approximation of its anterior and posterior sides. For it is principally by this force that the drinks are urged on continually, but the foods only when they are dissolved, lest those parts which are too gross should be expelled through the pylorus into the duodenum, when the stomach is more that way inclined by repletion; for the solid aliments do not seem to leave the stomach, before they have changed their fibrous or other texture for that of a mucous, as it were cineritious, yellowish, somewhat fetid, mucilaginous, and liquid pulp. That which is first prepared and turned fluid, goes before the rest out of the stomach; first water; then milk, pot-herbs, bread; and last of all, flesh-meats, the harder, tougher, and longer skins or fibres of which pass unchanged: but such things as are hard, or too large to pass the pylorus, are retained in the stomach for a long time.

But a considerable portion of the drink is absorbed by the pendulous exhaling vessels of the stomach itself, gaping like the exhaling arteries of the same part: so
3
their

their contents take a shorter way into the blood, as plainly appears from repeated experiments.

The stomach being irritated by too great a quantity or acrimony of the food, or else by sickness, a repulsion of the bile, or other cause, does, by an antiperistaltic or reverted motion of its fibres, drive its contents upwards through the open and relaxed œsophagus in the act of vomiting. Any part of the whole intestinal canal, from the pharynx to the rectum, may be constricted as well slowly by an antiperistaltic motion. If it happens suddenly to the upper parts at the stomach, the diaphragm being at the same time convulsed, and likewise the abdominal muscles, it is called *vomiting*; if it is slowly performed, it may be called *ruminatio*; if the small, and particularly the great intestines, return their contents upwards, the disease is called *ileus*. The effect of vomiting is partly from the pressure of the abdominal muscles depressing the false ribs, and urging the contents of the abdomen against the diaphragm; which, at the same time, contracting itself to a plane downwards, forces the stomach, as betwixt the sides of a press, to throw up its contents.

But the aliments driven in their natural course to the duodenum, meet there with the influent bile and pancreatic juice, which often flow back into the stomach.

From the exhaling arteries of the intestines distils a thin watery liquor into the cavity of the intestines, like the juice of the stomach, not acrid, but saltish. The quantity of this liquor may be computed from the large extent or sum of all the excretory orifices, and from the section or light of the secretory artery, larger than which we see no where in the body; add to this, the laxity of the parts perpetually kept warm and moist, and the copious diarrhœa or watery discharge that often follows the use of purgative medicines. But the mucus arising from the pores or cells before-mentioned serves to lubricate and defend the internal surface of the villous
1 membrane,

membrane, and to guard the sensible nerves from strongly acrid or pungent particles. Hence we see, it is more abundant at the beginning of the larger intestines, because there the mass of aliment begins to be more feculent, acrid, and tenacious.

The mixture of this liquor with the pulp-like mass of the aliment, together with the bile and pancreatic juice, is made by the motion of the surrounding muscles of the abdomen; but this force is quite small, and unfit for moving forward the aliments. But for this purpose serves especially the peristaltic motion, which is more particularly strong and evident in the small intestines. For any part of the intestine, irritated by flatus or any sharp or rough body, contracts itself, even after death, most violently in that part where the stimulus is applied, in order to free itself from the offending or distending body, which it expels into the next open part of the lax intestine; where, being received, it is again propelled forward, by exciting a like stimulus and contraction as before. This contracting motion of the intestines is made in various parts of the gut, either successively or at the same time, wherever the flatus or aliment excite a stimulus; and this, without observing any certain order. So well fitted, however, are the intestines for this motion, that they emulate, and even exceed, the irritability of the heart, or at least are scarcely exceeded by it. When they are not irritated, they remain at rest; and we may suppose this to be the cause why the fat remains in the belly. The air acts chiefly as a stimulus to the intestines, next to it is the aliment, and lastly the bile. This motion is performed by a wonderful sort of alternate creeping and revolution of the intestines, which dissection easily demonstrates in living brute animals, and unhappy cases of wounds in the abdomen and ruptures have manifested in the human species. And since here, among so many inflexions, the weight of the aliment is but of little force, it easily ascends or descends through the irritated

ted intestine, which thus empties itself. From hence the antiperistaltic motion is intelligible, by which the pulp of the alimentary mass is oftener or longer applied with a gentle force to the triture of the intestine, to the exhaling diluent liquor, and to the mouths of the absorbing veins. But all the contents of the intestine are determined downward to the large intestines, because the stimulus begins above, from the left opening of the stomach; and so, by the succession of new chyle, repeating the stimulus above the contraction, it descends, when there is no resistance made to it, into the lower part of the ileum, at its opening into the colon: here the loose part of this intestine readily receives what is pressed into it by the contraction from above, and as easily unloads itself into the large unactive cæcum; from whence it is again repelled upward, and in part urged on by the pressure of the succeeding mass. Anatomists observe, that this motion is made stronger downward than upward, and that the superior parts of the intestines are more irritable than the lower. But as often as an insuperable obstacle resists the passage of the aliment, there will be the seat of the principal contraction, and the aliment likewise is driven upward from the valve of the colon through the whole length of the intestines, into the stomach, and lastly into the mouth.

This peristaltic motion of the intestines is performed by the constriction of their circular fibres, which know how to empty the tube exactly, without injuring the intestine against pins, needles, or any other sharp bodies lodged within their contents, which they tenderly promote forward. But the revolutions of the intestines, drawn upward and downward, and the straightening of crooked parts of them one before another, which is so remarkably conspicuous in brute animals, are performed by the long fibres, which we see contract themselves at the seat of the present stimulus, and dilate the following portion of them to receive what ensues. By
the

the same contraction the villous membrane of the intestines, within their cavity, is urged and reduced into longer folds; whence the mucus is expressed and applied to that part of the alimentary mass, where it was required by the force of irritation and stimulus. These long fibres frequently make intro-susceptions of the intestines, and generally without any bad consequences, by drawing up the contracted portion of the intestine into that which is loose, in such a manner, that the former is surrounded by the latter, which is relaxed.

The alimentary pulp, therefore, diluted with the pancreatic juice and that of the intestines, intimately mixed with the saponaceous bile and circumjacent mucus, is more perfectly dissolved than by the efficacy of the stomach, in proportion as the sides of the intestines come into a larger contact, and approach nearer together; to which add, the longer series of the peristaltic motions, and the greater quantity of dissolving juices. In this manner the alimentary pulp, intermixed with air, forms a froth, without any kind of fermentation, which air is the same with what we commonly eructate from the stomach; but yet, at the same time, the acid or acedescence force is subdued, while the oily or fat parts, dissolved by the bile, intermix with the watery juices, and give the chyle its usual milky appearance, like an emulsion, of a bright colour in the duodenum, at the first entrance of the biliary duct; from whence downward it closely adheres to the villous coat of the small intestines. But the gelatinous juices of flesh meats, diluted with a large portion of water, and likewise from their own subviscid nature, do more particularly adhere to the villous coat, and enter it in the way of absorption. So water and watery liquors are all very greedily drank up by the absorbents; and yet the feculent remains never grow thick in the small intestines, as far as Haller has been able to observe, because the watery part is repaired by the arterial vapour and mucus; nor
do

do they become fetid in any considerable degree, as well because of the great quantity of diluting juices, as because the quick progression will not allow them time enough for a putrefaction. Those remains, which are of a more earthy, gross, and acrid disposition, which were excluded by the mouths of the absorbing lacteal orifices, do, by their weight, or by the muscular contractions, descend slowly into the large intestines, so as to complete their whole course in the space of about twenty-four hours. But within three, four, or a few more hours time, all the chyle of the aliment is commonly extracted.

The considerable length of the small intestine, which is five or more times longer than that of the body, the great surface of the villous membrane increased by folds, the incredible number of exhaling or absorbing vessels, the slow course of what remains through the large intestines, and the great quantity of the intestinal juice poured into the alimentary mass, do all of them concur in the small intestine, abundantly to perform what is required in the emulsions of the food for our healthy juices, and for their absorption into the lacteals and the mesenteric veins; also for absterfion of viscidities from the intestine; for the avoiding adhesions and coagulations; for the destruction of any acid disposition not yet subdued; and for the subduing any venomous quality in many juices; which, being directly mixed with the blood, instantly kill, but are thus sent in by the mouth without damage. Hence, in general, the intestines are long in animals that feed upon any hard diet, but short in carnivorous ones, and shortest in all those that live upon juices: and, even in man, an uncommon shortness of the intestines has been known to be attended with hunger, and a flux or discharge of fetid and fluid fæces.

The heat by which the aliment is fomented, and which is exceedingly proper for the solution of the gelatinous matter, and exciting a beginning putrefaction,
is

is hence the principal cause of the fetor which is gradually produced in the aliment; thence also is the cause of that thinness by which the useful part of the aliment is fitted for absorption. But the air also, inclosed in the viscid aliment, operates here, as in the stomach, by breaking the cohesion of the aliments, if any yet remain whole. The intestinal water dilutes the little masses of aliment; and if any hard part remains, this liquor softens it by maceration. The bile being intimately mixed with oil, dissolves the same, and renders it miscible with water.

What remains, after the chyle has been abstracted, consists of some portion of the bile, but mucilaginous and degenerate; some part of the human mucilages; most of the earthy parts that were lodged in the food; and all those parts which by their acrimony were rejected by the absorbing mouths of the lacteals, yet changed by means of putrefaction; with all the solid fibres and membranes, whose cohesion was too great to be overcome by the maceration and peristaltic motion in the intestines.

All these remains pass from the extremity of the ileum into the cæcum, in which they are collected and stagnate.

The intestinal feces, therefore, retained in the blind beginning of the colon or large intestine, there grow dry by the absorption of moist vapours, so as to be capable of receiving a figure from the round contracted parts of the colon; they ascend from the bottom of the cæcum elevated by the long ligaments, which end in the worm-like appendix. And here the manner in which the feces are propelled by the contraction of the circular fibres, appears better than in the small ones. The longitudinal fibres of the intestine, being attached to the contracted parts as fixed points, draw up and dilate the lower parts of the intestine; then the next parts of the intestine, to which the feces are brought, being irritated and contracted in like manner, are immediately after drawn together by the round and

long fibres; by a successive repetition of which the feces finish their course entirely, through the whole large intestine for the most part in twenty-four hours in a healthy person. For wounds in mankind, and the comparative anatomy of brute animals, demonstrate this peristaltic motion of the intestines to the eye; which is also confirmed by the antiperistaltic motion, and its consequences, by which the matter of glysters is returned up through the mouth. The same fibres resist the air contained in the intestines; and wind is said to be generated as often as these fibres being overcome by its impulse yield, and the intestine is dilated.

While the gross feces ascend by the folds or valves of the ileum, the weight of them depresses the lower fold to the left side, which draws back the ligament common to each valve, in such a manner as to compress and exactly close the upper fold downward, that nothing may return back into the ileum; which might easily happen in a fluid state of the feces, if this port was not so accurately shut up. The feces, when in danger of falling down from the upper parts, depress the upper valve, and thus accurately exclude themselves. This happens very exactly with the feces, but not so accurately with water. From thence they continue to move slowly forward, more dry, consistent, and figured by the same causes through the whole tract and repeated flexures of the colon, which is sometimes of five or seven feet in length, so as to retain the feces a space of time sufficient to give no interruption to the affairs of human life; and this time is proportionably less than twenty-four hours, the greater the velocity with which the small intestines propel their contents.

At length the figured excrement falls into the *rectum*, which is inflected first a little downwards and then forward, of a broad depressed figure, at first descending contiguous to, and afterwards spread under, the bladder or vagina, but connected more with the former than the latter. Here, for a great while, and often to

a great quantity, the feces are collected together, in a part which is loose, or openly furrounded with soft viscera and muscles, with a good deal of fat.

The structure of the rectum differs very much from that of the other intestines. The external membrane or peritonæum is only spread before it; while behind it is supported by a broad stratum of the cellular substance, replenished with fat, and many conglobate glands, connecting this intestine all the way to the os sacrum. The muscular fibres in this intestine are much stronger and more numerous, more especially the longitudinal ones, than in the other intestines; being composed of the three ligaments of the colon, expanded and separated first over the anterior face, and then over the whole intestine; which they dilate against the advancing feces, and draw back the intestine after it has excluded them. But the transverse fibres are also strong; and the last of them are oval, forming a protuberant ring, which is the internal *sphincter* itself, by which the opening of the anus is closed.

Moreover, the villous tunic, extremely full of pores, and of a rough surface, full of reticulated polygonous and tender wrinkles, has likewise some sinuses peculiar to itself. Namely, that part of the intestine which is next to the skin or outward opening, forms a white firm circle like a valve, into which descend the longitudinal folds, but incurvated and approaching one to another in the circle itself. Betwixt those folds are intercepted sinuses, hollow upwards, and of a greater depth towards the lower extremity of the intestine. Into the cavity of these open the mouths of the large mucous glandules; while the margin of the anus itself is defended by sebaceous glandules, that it might not be excoriated by the harder acrid feces.

There are also proper muscles which govern the anus. Of these the outermost is the *sphincter*, which is broad and fleshy, consisting of two plates of half elliptic fibres, which cross each other towards the coccyx, and to-

wards the genital parts. And there they are inserted by fleshy bundles into a callous cellular fabric descending from the coccyx. But forward, they are firmly attached, by dense portions of the same kind, to the skin of the perinæum; but by three stronger portions in the middle, and two in the sides, they are inserted into the bulb of the urethra, whose lateral parts they surround, betwixt the sphincter and levator. The fibres, therefore, of the sphincter, placed betwixt the anterior and posterior face of the rectum, ascending in a direct course, close the opening of the anus, which they surround. With the internal sphincter, the external one is conjoined by fleshy portions, that they may co-operate together. The constriction of them is not perpetual but voluntary; for the anus seems to close itself naturally, if the smallness of its opening be compared with the largeness of the intestine above, and with the corresponding wrinkle, aided by the strength of the transverse fibres of the internal sphincter and the incumbent bladder.

But there is another office belonging to the *levators*, which are broad complicated muscles. They descend broadly from betwixt the opposite protuberances of the ossa ischia, placed under the rectum and bladder; and serve to sustain the rectum on each side, and prevent it from subsiding, or from an unsightly eversion. Moreover, the same fibres of the levator, declining broadly from each other, in the nature of a sphincter, to which they join, serve to dilate its orbicular fibres, and open the anus; but, at the same time, they both elevate and sustain the intestine from prolapsing downward by the pressure of the hard feces. They arise, as is well known, from the spine of the ischium, os ileum, and synchondrosis of the ossa pubis, terminated by the margin of the great foramen of the pubes, and that part of the ischium which is above the tubercle. Finally, they meet together in one above the coccyx, into which they are inserted by numerous fibres.

Therefore,

Therefore, whenever the feces are collected to some quantity within the rectum, so as to be troublesome by their weight, irritation, or acrimony, they excite an uneasiness through the adjacent viscera; and are then urged downward by a voluntary pressure through the straits of collapsed intestine by the force of the incumbent diaphragm exciting an effort; which urging downward with great force, the viscera of the abdomen, which is always full, are determined downward through the inner rim of the pelvis, so as to urge upon the contents of the less resisting bladder and rectum. When the resistance of the anus is thus overcome, the compressing forces of the diaphragm abate, and the feces continue to discharge from the body, urged only by the peristaltic motion itself of the intestine. After the feces are expelled, the intestine is drawn back or up into the body by its longitudinal fibres; after which the opening of the anus itself is closely contracted by the two proper sphincters as at first. These feces in men and carnivorous animals are very foetid, almost putrid, subalkaline, soft, and contain much oil intimately mixed with salts, which are left both by the aliments, as well as by the bile and other humours of the human body. An acrid and foetid water returns from the feces into the blood; hence costiveness in fevers is hurtful, putrefaction being increased by the affusion of the above-mentioned matter into the body.

§ 13. *Hepar, and Vesicula Fellis.*

Situation, figure, and division, of the liver. The liver is a large and pretty solid mass, of a dark red colour, a little inclined to yellow, situated immediately under the arch of the diaphragm, partly in the right hypochondrium, which it fills almost entirely, and partly in the epigastrium, between the appendix ensiformis and spina dorsi, and terminating commonly in the left hypochondrium,

chondrium, into which it sometimes runs a considerable way.

The figure of the liver is irregular, it being arched or convex on the upper part, unequally concave on the lower, and very thick on the right and back sides. Towards the left and anterior sides, its thickness decreases very much, and terminates there by a kind of edge; and it is broader from right to left than from before backwards.

The liver may be divided into two extremities, one great, the other small; two edges, one anterior, and one posterior; two sides, one superior and convex, which is smooth, polished, and proportioned to the arch of the diaphragm, and one inferior, concave and uneven, with several eminences and depressions; of which hereafter.

It may likewise be divided into two lateral parts, called *lobes*; one of which is termed the *great* or *right lobe*, the other the *small* or *left lobe*. These two lobes are distinguished above by a membranous ligament, and below, very plainly, by a considerable scissure, lying in the same direction with the superior ligament.

The eminences on the concave side of the liver belong to the great lobe. The principal eminence is a sort of triangular or pyramidal apophysis, situated backward near the great scissure which distinguishes the two lobes.

This triangular eminence is termed simply the *small lobe of the liver*, or *lobulus Spigelii*, though it was known to several anatomists long before his time. One of its angles advances a considerable way toward the middle of the lower side of the great lobe, and is lost there. This angle we call the *root* of the lobulus. Toward the fore-side there is another eminence less prominent, but broader; and to this eminence, and the former, the ancients gave the general name of *porta*.

The depressions on the concave or lower side of the liver, which deserve our attention, are four in number.

The

The first is the scissure that separates the two lobes, which runs across the concave side, from the eminences already mentioned, to the anterior edge, where it terminates by a notch of different depths in different subjects. This is termed the *great scissure* of the liver; and in some subjects part of it is an entire tube. The second depression is situated transversely between the two eminences of the great lobe, and filled by the sinus of the *vena portæ*, so called by the ancients because it lies between the eminences of the same name. The third depression is backward between the great lobe and lobulus Spigelii, and the vena cava passes through it. The fourth is a kind of sulcus between the lobulus and small lobe of the liver, which in the fœtus served to receive a venal canal lost in adults, in whom it appears only as a kind of ligament. This sulcus is in some measure a continuation of the great scissure, and joins the vena cava by an acute angle.

Besides these four depressions, there is one on the fore-part of the great lobe, in which the vesicula fellis is lodged; and it sometimes runs as far as the edge, where it forms a small notch. We may likewise reckon among these depressions a small superficial cavity in the posterior and lateral part of the lower side of the great lobe, by which it rests on the right kidney; and likewise a superficial cavity in the left lobe, where it runs over the stomach.

Lastly, on the posterior edge of the liver, there is a great sinus common to both lobes, which gives passage to the spina dorsi and œsophagus, near the place where the vena cava descends; and we sometimes meet with scissures on both sides of the liver, which are not ordinary.

Ligaments of the liver. The convex side of the liver is commonly connected to the diaphragm by three ligaments, which are only continuations of the membranous lamina of the peritonæum. One lies near the edge of the extremity of each lobe, and one in the

middle ; and they are accordingly termed the *right*, *middle*, and *left ligaments*. There is a cellular substance in the duplicature of each, in which the blood-vessels and lymphatics run, and which sends off a kind of lamina into the substance of the liver.

The right ligament sometimes connects the great lobe to the cartilages of the false ribs ; and the left ligament, or that of the small lobe, is often double, and advances toward the middle ligament. This middle ligament begins below in the great scissure of the liver, near the eminences called *portæ* ; and from thence passes through the anterior notch, and over the convex side of the liver at the union of the two lobes, and is fixed obliquely in the diaphragm.

It is likewise fixed along the upper and inner part of the vagina of the right musculus rectus of the abdomen, in such an oblique manner as to be nearer the linea alba below than above.

Besides these ligaments, the great lobe of the liver is likewise connected to the right ala of the tendinous portion of the diaphragm, not by a ligament, but by a broad and immediate adhesion, without the intervention of the membrane of the peritonæum, which is only folded quite round this adhesion, to form the external membrane of all the rest of the body of the liver.

This broad adhesion is commonly, though improperly, called *ligamentum coronarium* : but, in the first place, it is not a ligament, as has been already observed ; and, secondly, it is not circular, but oval and very oblong.

It is not on the upper part of the convex side of the liver, but along the posterior part of the great lobe ; the broad extremity of the adhesion lying nearer the notch, and the pointed extremity towards the right hypochondrium.

The middle ligament, called improperly *ligamentum hepatis suspensorium*, contains in its duplicature a thick white rope, like a round ligament, which was the umbilical

bilical vein in the foetus. Thus the lower part represents a falx; the convex edge of which is sharp, and the other rounded.

All these ligaments serve to keep the liver in its proper situation, and to hinder it from inclining too much towards either side; but we must not imagine that any of them serve to suspend it; because it is sufficiently supported by the stomach and intestines, especially when they are filled.

When the stomach is empty, or when we fast longer than ordinary, it is a common expression to say the stomach pinches us. As the liver is not then sustained by the stomach and intestines, it descends by its own weight, and, chiefly by means of the middle ligament, pulls the diaphragm along with it. It is in that place, therefore, that we have this uneasy sensation; and not at the superior orifice of the stomach, as is commonly believed.

The right or great lobe of the liver, which lies in the right hypochondrium, rests on the right kidney by a small superficial depression above-mentioned; and it likewise covers a portion of the arch of the colon and the pylorus. About two third parts of the small or left lobe lie in the middle of the epigastrium, and the remaining third part advances over the stomach towards the left hypochondrium.

This small lobe is situated almost horizontally; the great lobe is very much inclined, and its thick extremity runs down almost in a perpendicular direction to the right kidney on which it lies, in the manner already said. This observation is of use to distinguish the different parts of the liver in wounds and surgical operations.

It may likewise serve to direct us in examining a liver taken out of the body; the situation of which may be otherwise very easily mistaken, especially that of the parts of the concave side. The passage of the vena cava, between the body of the great lobe and the lobulus Spigelii,

Spigelii, may likewise serve for a rule in placing a detached liver in its true situation.

Structure of the liver. The liver is composed of several kinds of vessels; the ramifications of which are multiplied in an astonishing manner, and form, by the intertexture of their capillary extremities, an innumerable collection of small pulpy friable corpuscles, which are looked upon to be so many organs designed to separate from the mass of blood a particular fluid, termed the *bile*.

The greatest part of these vessels, from one end to the other, is included in a membranous vagina, called *capsula venæ portæ*, or *capsula Glissoni*, from an English author who first described it particularly, about the middle of the last century. This vagina is commonly considered as a continuation of the membrane which covers the liver, and which penetrates this substance along with the blood-vessels; but Sabatier is of opinion it is a continuation of the cellular membrane which covers the *vena porta ventralis*.

The vessel which carries the blood to the liver is called *vena portæ*, for the reason already given. In the description of the veins, we observed that the *vena portæ* might be considered as two large veins, the trunks of which are joined endwise, and send out branches and ramifications in opposite directions to each other; that one of these veins is ramified in the liver, the other lying without the liver, and sending its branches and ramifications to the viscera of the abdomen; and, lastly, that the first of these large veins may be termed *vena portæ hepatica*, the other *vena portæ ventralis*.

Vena portæ hepatica. The particular trunk of the *vena portæ hepatica* is situated transversely between the broad anterior eminence of the great lobe of the liver and the root of the lobulus in a particular scissure, and forms what is called the *sinus of the vena portæ*. From this sinus five principal branches go out, which are afterwards

wards divided into millions of ramifications through the whole substance of the liver.

At this place the vena portæ lays down the common office of a vein, and becomes a kind of artery as it enters, and is again ramified in the liver. The extremities of all these ramifications of the trunk of the vena portæ hepatica end in the pulpy friable corpuscles of the liver.

Pori bilarii et ductus hepaticus. It is in these corpuscles that the bile is secreted ; and it is immediately collected in the same number of extremities of another kind of vessels, which unite, by numerous ramifications, into one common trunk. These ramifications are termed *pori bilarii*, and the trunk *ductus hepaticus* ; and the ramifications of these two kinds of vessels are invested together by the capsula of the vena portæ.

Hepatic veins. The blood deprived of this bilious fluid is reconveyed to the heart by a great number of venal ramifications, which afterwards unite into two or three principal branches, besides others that are less considerable, that terminate in the vena cava, and are all called by the name of *vena hepatica*.

The capillary extremities of the ramifications of the vena hepatica, join those of the vena portæ, and accompany them through the liver ; and yet the great branches of both veins intersect each other in several places.

When we cut the liver in slices, it is easy to distinguish in each slice the ramifications of the vena hepatica from those of the vena portæ ; the first being thinnest and largest, and adhering closest to the substance of the liver ; whereas those of the vena portæ, which are invested by the cellular capsula, appear to be a little ruffled when empty ; because the cellular capsula subsides when it is cut, but the other veins remain uniformly open, their sides adhering to the substance of the liver ; besides, they are accompanied by branches of the hepatic

patic artery and biliary ducts, which do not follow those of the *venæ hepaticæ*: and Sabatier observes, that the direction of the branches of the *venæ hepaticæ* is perpendicular to that of the *vena portæ*.

Hepatic artery and nerves. The liver receives from the *arteria cæliaca* a particular branch, termed *arteria hepatica*; which being very small when compared with the bulk of that viscus, seems designed only for the nourishment thereof, and not for the secretion of the bile. The plexus hepaticus, formed by the *nervi sympathetici maximi et medii*, furnishes a great number of nerves to the substance of the liver. The ramifications of the artery and nervous plexus are included in the cellular capsula, together with those of the *vena portæ* and *pori bilarii*.

The pulsation of this artery has been by some anatomists taken for that of the capsula, which they supposed to be muscular; and by this they have endeavoured to explain the arterial function of the *vena portæ*: but they have not considered, that the blood in this vein does not require to be pumped forward; because so swift a motion would have been prejudicial to the secretion of the fine oil of the bile, for which a slow and almost insensible motion is necessary. Cowper and Santorinus were the first who doubted of the muscular nature of the capsula, and they have been followed in this by modern anatomists.

The liver is covered exteriorly by a particular membrane or coat, which is a continuation of the peritonæum. There is likewise a membranous or filamentary substance that runs through this whole viscus, and connects the ramifications and extremities of all its vessels to each other. This substance seems to be a complicated production of the capsula of the *vena portæ*, and of the external membrane of the liver.

The outer surface of this coat is very smooth, but its inner surface is uneven, being made up of a great number of thin membranous laminæ; between which

we observe, very distinctly, numerous lymphatic vessels, on both the convex and concave sides of the liver; but it is more difficult to trace those which accompany the filamentary substance through that viscus. Some of the lymphatic vessels from the substance and concave surface of the liver run in the capsul of Glisson; and after passing through conglobate glands situated there, they end at last in the receptaculum chyli, or into some of the large lacteals; others, upon the convex surface of the liver, run to the ligamentum susperiorum, from which they pierce the diaphragm in company with the vena cava, to end in the thoracic duct.

We have already observed, that the substance of the liver is chiefly made up of an infinite number of pulpy friable corpuscles; each of which is bounded, and in a manner surrounded, by a particular expansion of the capsula Glissoni; and all these expansions are connected by common septa, in some measure resembling a bee-hive.

These corpuscles have several angles, especially in the inner surface of the liver; but near the surface they are raised in the form of small tubercles. Their pulpy texture appears like radiated villi, a small void space being left in the middle of each.

If we blow through a pipe into the vena portæ, vena cava, arteria hepatica, or trunk of the pori bilarii, but especially through the two veins, we observe the liver to swell, and the corpuscles near the surface are raised, and become more sensible. If we blow with much force, we burst these corpuscles; and the air getting between them and the external membrane, raises it from the substance of the liver in blisters.

Ductus cholidochus. The ductus hepaticus, or trunk of the pori bilarii, having run a little way, joins another canal, called *ductus cysticus* or *vesicularis*; because it comes from the vesicula fellis, as we shall see in the description of that organ. These two united ducts
form

form a common trunk, named *ductus cholidochus*; because it conveys the bile. This duct having reached the incurvation of the duodenum, insinuates itself thro' the coats of that intestine, and opens into the cavity thereof, not by a round papilla, but by an oblong orifice rounded at the upper part, and contracted at the lower like the spout of an ewer, or like a common tooth-picker.

The edges of this orifice are raised, broad, and plaited, as we may see by making this portion of the duodenum swim in clear water. At the entry of this orifice we see another small opening distinct from it, which is the orifice of the *ductus pancreaticus*; of which hereafter. Glisson was of opinion, that the extremity of the *ductus cholidochus* was furnished with a sphincter of muscular fibres, which was capable of shutting the orifice and of preventing the contents of the duodenum from entering it; but no such duct has been found by others, and the obliquity of the passage answers the same purpose.

Vesicula fellea. The gall-bladder is a kind of small bag, shaped like a pear; that is, narrow at one end, and wide at the other. The wide extremity is termed the *fundus* or *bottom*, the narrow extremity the *neck*, and the middle portion the *body*. About one third of the body of the vesicula lies in a depression on the concave side of the liver, from the trunk or sinus of the *vena portæ*, where the neck is situated, to the anterior edge of the great lobe, a little toward the right side, where the bottom is placed; and in some subjects it advances beyond the edge, so as to oppose itself to the muscles of the abdomen under the edges of the false ribs.

Therefore when we stand, the vesicula fellea lies in a plane inclined a little from behind forward. When we lie upon the back, it is almost inverted. When we lie on the right side, the bottom is turned downward, and it is turned upward when we lie on the left side; and

these situations vary according to the different degrees of each posture.

The gall-bladder is composed of several coats; the outermost of which is a continuation of that which invests the liver, and consequently of the peritonæum.

The under side of the gall-bladder touches the colon at the beginning of the duodenum, and sometimes at the pylorus.

The second coat is said by some to be fleshy, and made up of two strata; one longitudinal, the other transverse, like that of the stomach or intestines; but excepting in some very robust subjects, there are scarcely any muscular fibres to be seen.

A whitish stratum is looked upon as the third coat of the gall-bladder, answering to the tunica nervosa of the intestines.

The innermost, or fourth coat, has on the inside a great number of reticular folds, filled with small lacunæ, like perforated papillæ, especially near the neck of the vesicula, where these folds are longitudinal, and afterwards form a kind of small pylorus, with plaits of the same nature with those in the great one. These lacunæ are looked upon to be glands. Sabatier admits only of the first and the last of these coats; and considers the intermediate substance as being merely cellular and vascular.

That side of the body of the vesicula which lies next the liver is connected to that viscus by a vast number of filaments, which run a great way into the substance of the liver. Among these fibres, in some animals, ducts have been observed a long time ago. They are most numerous near the neck of the vesicula; and they are named *ductus cysto-hepatici*, or *hepatico-cystici*: but no such ducts can be demonstrated in the human body.

The neck of the vesicula is formed by the contraction of the small extremity; and this neck bending afterwards in a particular manner, produces a narrow canal,

nal, named *ductus cysticus*. This incurvation represents, in some measure, the head of a bird, of which the cystic duct, by the gradual diminution of its diameter, expresses the beak. This cannot be seen when the liver is *extra situm*; and even *in situ* it is but very imperfectly seen, when, in order to view the concave side, the liver is raised and thrust too much against the diaphragm; for by thus inverting the liver, the curvature is disordered, and we see two in the place of one.

To see this curvature in its true natural situation, the liver is to be raised but very little, and the duodenum left untouched; then we must stoop and look under the liver, without disordering any thing. This incurvation may be of use to hinder too precipitate a discharge of the bile contained in the vesicula, which some situations of the body might occasion.

The neck of the vesicula is nearly of the same structure with the other parts. It has on the inside several reticular rugæ and some folds, which appear like fragments of *valvulæ conniventes*, situated very near each other, from the neck to the contraction of the cystic duct. The first of these folds is pretty broad and large, and almost circular; the next is more oblique and smaller in size, and the rest diminish in the same manner. Taken all together, they form a kind of spiral flight, which may be seen through the neck on the outside, where it sometimes appears like a screw, especially when the neck is filled with any fluid. This observation is owing to M. Heister.

By flitting the neck and duct, we see all these folds very distinctly, especially when we examine them in clear water. When they are viewed in any other manner, they easily deceive us, being mistaken for true valves, because of their transverse situation. They may, however, in some measure, supply the place of valves, by hindering the bile from running too fast into the duodenum, and the contents of the duodenum from entering this duct. The structure of the biliary ducts

ducts appears to be entirely membranous, covered externally with a thick cellular substance, and lined within by a kind of tunica villosa, which is pierced with numerous holes, that make it appear like a sieve. Through these a mucous humour flows to save the ducts from the impression of the bile. And the internal surface of all these biliary ducts, that is, of the ductus hepaticus, cysticus, and cholidochus, being examined through a microscope in clear water, appears to be nearly of the same structure through their whole extent.

The cystic and hepatic ducts do not, in their ordinary and natural situation, represent the capital Y of the Greeks, where they form the ductus cholidochus. After the incurvation of the neck of the vesicula, these two ducts run very near each other, and they appear to be separated only by raising up the liver to view them. The same disorder happens in an inverted liver extra situm; for then the body of the liver subsides, and is flattened, and thereby separates the ducts; whereas, in its true situation, it is very much incurvated, and the ducts very near each other.

The ductus cholidochus appears rather to be a continuation of the ductus cysticus than the common trunk of that and of the ductus hepaticus: for this last duct runs for some space within the sides of the former, before it opens into the cavity; much in the same manner as the ductus cholidochus passes into the duodenum. Winslow has observed, at the opening of the hepatic into the cystic duct, a small loose valvular membrane, which may hinder the bile from returning out of the ductus cholidochus into the hepaticus. But later anatomists describe only a sharp angle at the meeting of the cystic and hepatic ducts similar to the bifurcation of the arteries or veins.

The bile, which passes through the ductus hepaticus into the cholidochus, may be called *hepatic*; and that which is collected in the vesicula fellis, may be termed

cystic. The hepatic bile flows continually through the ductus cholidochus into the duodenum; whereas the cystic bile flows only by reason of plenitude or by compression.

Remarks on the vessels, &c. of the liver. The trunk of the vena portæ ventralis terminates between the lobe and the opposite part of the great lobe; and there joins the trunk of the vena portæ hepatica in the transverse sinus of the liver, between the right extremity and the middle of that sinus.

The umbilical ligament, and consequently the umbilical vein in the fœtus, joins the trunk of the vena portæ hepatica toward the left extremity of the transverse sinus of the liver. The canalis venosus in man is not exactly opposite the vena umbilicalis, but a little to the right hand; and therefore these three vessels lie in such a direction as to form two opposite angles, resembling those of the handle of a wheel or of a spit.

In the fœtus, therefore, the blood which comes from the umbilical vein does not run directly through that contained in the vena portæ hepatica in the sinus, and from thence into the canalis venosus; but is obliged to turn from left to right, and so to mix with the blood in the vena portæ, before it enters that canal which opens into the trunk of one of the great hepatic veins of the vena cava near the diaphragm.

The hepatic vena portæ gives off commonly five large branches into the liver, viz. three from its right extremity into the great lobe, and two from its left extremity into the small lobe; and from the interstice between these, a small branch goes directly to the middle of the convex side of the liver.

The hepatic veins are commonly two or three large branches, which go into the trunk of the vena cava by one common opening, especially two of them. In the substance of the liver, they intersect the branches of the hepatic vena portæ, and are ramified in all directions in the manner already explained. The inferi-

or portion of the opening of these veins into the vena cava, forms a kind of semilunar valve.

Below these hepatic veins, the vena cava inferior, in its passage by the liver, receives several other small hepatic veins, which seem to have the same relation to the hepatic artery as the great veins to the vena portæ.

The passage of the vena cava is through the right portion of the posterior sinus of the liver, and consequently on the side of the great lobe, which is hollowed at this place sufficiently to give passage to the vein, of which it surrounds about three-fourths, sometimes more, and sometimes the whole.

This passage answers to the interstice between the lobulus and the rest of the great lobe; and its direction is, in the natural state, from below upwards, and a little from left to right: but when the liver is viewed extra situm, and inverted, it appears very oblique; but still it serves as a guide to beginners, who are very apt to be mistaken in examining an inverted liver.

The trunk of the great vena portæ, the hepatic arteries, the ductus hepaticus, or trunk of the pori bilarii, and the nerves of the plexus hepaticus, form all together a large bundle before they enter the liver. The trunk of the hepatic vena portæ is in the middle of this bundle; the hepatic arteries lie on the right and left sides of this trunk, the nerves surround it on all sides, and they communicate with the plexus mesentericus superior.

Afterwards the first branches of the arteries, nerves, and pori bilarii, leave the trunk of the great vein, and join in the same manner the trunk of the small or hepatic vena portæ, and its ramifications in the capsula Glissoni explained above.

All these branches of the vena portæ, and of the arteries, nerves, and pori bilarii, accompany each other by ramifications through the whole substance of the

liver, forming every where small fasciculi, in the same manner as the large bundles formed by their trunks. Each ramus of the vena portæ, artery, nerve, and porus bilarius, has a proper vagina, and all the four have a common vagina distinguished from the former cellular septa, which are only continuations of the vaginæ of both kinds.

The convex side of the common cellular vagina is connected quite round to the substance of the liver by numerous filaments which arise from it, and which form the cellular substance found between the glandular corpuscles. The concave side produces the cellular septa above-mentioned.

In this common vagina, the vessels, ducts, and nerves, are disposed in such a manner, as that the rami of the vena portæ chiefly fill the cavity of it; and lie in a lateral situation: the arterial ramus and porus bilarius lie together on the side of the vein, and the nerve is divided into several filaments, which run in between the vessels and ducts, and chiefly accompany the artery and porus bilarius; the vena portæ having by much the fewest.

The uses of the liver shall be explained after the description of the pancreas, spleen, and omentum, all these viscera having a great relation to the liver.

§ 14. *Pancreas.*

Figure, division, and situation, of the pancreas. The pancreas is a long flat gland, of that kind which anatomists call *conglomerate*, situated under the stomach, between the liver and the spleen. Its figure resembles that of a dog's tongue; and it is divided into two sides, one superior, the other inferior; two edges, one anterior, the other posterior; and two extremities, one large, which represents the basis of a tongue, and one small and a little rounded like the point of a tongue.

The

The pancreas is situated transversely under the stomach, in the duplicature of the posterior portion of the mesocolon. The large extremity is connected to the first incurvation of the duodenum, and from thence it passes before the rest of that intestine all the way to its last incurvation; so that a great part of the duodenum lies between the pancreas and the vertebræ of the back. The small extremity is fixed to the omentum near the spleen.

Structure of the pancreas. The pancreas is composed of a great number of soft glandular molecu læ, combined in such a manner, as to exhibit the appearance of one uniform mass on the outside, the surface of which is rendered uneven, only by numerous small convexities, more or less flattened. When these molecu læ are separated a little from each other, we find, along the middle of the breadth of the pancreas, a particular duct, in which several smaller ducts terminate laterally on each side, like small rami in a stem.

This canal, named *ductus pancreaticus* or *ductus Virsungi*, from the discoverer of it in the human body, is very thin, white, and almost transparent, and the extremity of the trunk opens commonly into the extremity of the ductus cholidochus. From thence it diminishes gradually, and terminates in a point, next the spleen. The small lateral branches are likewise pretty large near the trunk, and very small toward the edges of the pancreas, all of them lying in the same plane like the branches of the common filix or fern.

The pancreatic duct is sometimes double in man, one lying above the other. It is not always of an equal length, and sometimes runs in a winding course, but always in the same plane; and it is nearer the lower than the upper side of the pancreas. It pierces the coats of the duodenum, and opens into the ductus cholidochus, commonly a little above the prominent point of the orifice of that canal; and sometimes it opens immediately into the duodenum.

The small pancreas. In man, Winslow observed, that where the great extremity of the pancreas is connected to the curvature of the duodenum, it sends down an elongation, which adheres very closely to the following portion of the intestine; and, upon a careful examination, he found a particular pancreatic duct ramified like the large one, which ran toward and intersected this great duct, into the extremity of which it opened, after having perforated the duodenum. This portion he termed *pancreas minus*. It sometimes opens separately into the duodenum, in which we likewise observe several small holes round the ductus cholidochus, which answer to the pancreas.

Blood-vessels and nerves of the pancreas. The arteries of the pancreas come from the pylorica, duodenalis, and chiefly from the splenica, which adheres very closely to the whole lower side of the pancreas near the posterior edge, and it sends off in its passage a great many rami named *arteriæ pancreaticæ*, which go off from each side, more or less transversely. It receives also some small ramifications from the gastrica major and mesenterica superior.

The pancreatic veins are rami of the splenica, one of the principal branches of the vena portæ major or ventralis. This vena splenica runs likewise along the lower side of the pancreas near the edge, in a shallow depression formed in the substance of the gland. These veins answer to the arteries of the same name; and there are likewise other small veins corresponding to the small arteries, which are productions of the great meseraica, &c.

The nerves of the pancreas come partly from the plexus hepaticus, partly from the plexus splenicus, and partly from the plexus mesentericus superior, and it likewise receives some from the flat ganglion or plexiform intertexture, mentioned in the description of the nerves, by the name of the *transverse rope*.

The pancreatic duct is not only double in some subjects,

jects, as has been said, but the collateral branches have communications in form of islands in several places, within the body of the pancreas.

The pancreatic juice, which is watery, insipid, thin, neither acid nor alkaline, is poured into the same place into which the bile discharges itself. The quantity of juice secreted by the pancreas is uncertain; but it must be very considerable, if we compare the bulk or weight of it with that of the salival glands; than which it is three times larger, and seated in a warmer place. It is expelled by the force of the circulating blood, with an alternate pressure from the incumbent and surrounding viscera; as the liver, stomach, spleen, mesenteric and splenic arteries, with the aorta. The great usefulness of this gland may appear from its being found not only in man, but almost in all animals: nor is its use the less from that experiment which shows a great part of it may be cut out from a robust animal without occasioning death; because, in the experiment, a part of the pancreas must be left with the duodenum. Its effervescence with the bile arises from the effect of a ligature, and air mixed with the intestinal humour.

The pancreatic juice seems principally of use to dilute the viscid cystic juice, to mitigate its acrimony, and mix it with the food. Hence it is poured into a place remote from the cystic duct as often as there is no cystitis. Like the rest of the intestinal humours, this juice dilutes the mass of aliments, resolves them, and does every other office of the saliva.

§ 15. *Lien.*

Situation, division, and figure of the spleen. THE spleen is a bluish mass, something inclined to red, and of a long oval figure, being about seven or eight fingers breadth in length, and four or five in breadth. It is of a softish substance, and is situated in the left hypochondrium, between the great extremity of the sto-

mach, and the neighbouring false ribs, under the edge of the diaphragm, and above the left kidney.

It may be naturally divided into sides, edges, and extremities. It has two sides, one external and gently convex, and one internal which is irregularly concave; two extremities, one posterior which is pretty large, and one anterior which is smaller and more depressed; two edges, one superior, and one inferior, on both which there are, in some subjects, several inequalities.

The inner or concave side is divided by a longitudinal groove or scissure, into two planes or half sides, one upper, the other lower; and, by this groove, the vessels and nerves enter in human subjects. The superior half side is broader and more concave than the inferior, being proportioned to the convexity of the great extremity of the stomach. The inferior half side lies backward on the left kidney, and forward on the colon; and sometimes this side of the spleen appears to have two superficial cavities, one answering to the convexity of the stomach, the other to that of the colon. The convex side of the spleen is turned to the left ribs.

It is connected to the stomach by the vessels called *vasa brevia*; to the extremity of the pancreas, by ramifications of the splenic artery and vein; and to the omentum, by ramifications which the same artery and vein send to the spleen, and which run in the longitudinal groove.

It is connected to the edge of the diaphragm by a particular membranous ligament of different breadths in different subjects, fixed in its convex side, sometimes near the upper edge, and sometimes near the lower. This ligament is situated transversely with respect to the whole body, and longitudinally with respect to the size of the spleen. In some subjects, it is connected by other ligaments to the stomach and colon; but in all this there are considerable varieties.

The figure of the spleen is not always regular, and is as various as the size. Sometimes it has consider-

able scissures both in the sides and edges, and sometimes it has appendices. I have sometimes found a kind of small distinct spleens, more or less round, and connected separately to the omentum, at some distance from the anterior extremity of the ordinary spleen.

Structure of the spleen. The structure of the spleen is not easy to be unfolded in man; and it is very different from that of the spleens of brutes.

Its coverings adhere to it so closely in man, that it is difficult to distinguish the common from the proper coat; whereas in some brutes, such as oxen, sheep, &c. nothing is more easy; for in such animals we find two coats separated by a cellular substance. This covering seems to be no otherwise a continuation of the peritonæum than by the intervention of the omentum and mesocolon; and even in man the two coats may be distinguished, where the vessels enter by the longitudinal scissure.

In man, the substance of the spleen is almost wholly vascular, that is, composed of the ramifications of all kinds of vessels. In oxen, the substance of the spleen is chiefly reticular, and in sheep it is cellular. In oxen and sheep, there are no venal ramifications; but instead thereof, only open sinuses disposed like branches, except a small portion of a venal trunk perforated on all sides, at the extremity of the spleen.

Structure and use of the spleen. The spleen is one of those viscera which send their blood to the liver. The situation of it varies with that of the stomach itself, which it follows. When that is empty, the spleen is raised perpendicularly, so as to place its extremities right up and down: but when the stomach is full, the middle curve or arch of it arises upward and forward; and at the same time obliges the spleen to change its situation, so as to lie almost transversely with its lower end forward, and its upper end backward. Thus, being of a very soft and loose texture, it grows larger by distension when the stomach is empty, and becomes less

less again when its blood is pressed out by the distension of the full stomach against the ribs. From hence the spleen is found large in those who die of lingering diseases; but in those who die suddenly, and in full health of body, it is small. Another motion of the spleen is, that of descending with the diaphragm in inspiration, and ascending again in expiration; and besides this, the spleen frequently varies in its situation with that of the colon. Frequently there is a second or less spleen placed upon the former.

The *blood-vessels* of the spleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the upper branch of which, proceeding in a serpentine course above and behind the pancreas, to which it gives branches, as well as to the mesocolon, stomach, and omentum, is at length incurvated in the direction of the sulcus or notch of the spleen, which it, after a manner, perforates by several distinct branches, sustained at the right extremity by the omentum gastrocolicum. The thickness of this artery is greater than that of the aorta. The splenic vein, which accompanies the artery, is considerably softer than any other veins of the body; it forms the principal left branch of the vena portarum. Besides these, the spleen receives small arteries from the great coronary descending behind the pancreas, and sometimes from the internal hæmorrhoidal. The vasa brevia of the spleen and stomach we have mentioned elsewhere; and its ligaments and membranes receive small arterial twigs from the lumbar arteries, phrenics, intercostals, and those of the renal capsules. In like manner also the veins in the spleen, and those which join it to the stomach, communicate with the phrenics, and with the veins of the renal capsules.

The *lymphatic vessels* of the spleen arise in the duplication of the splenic coat or membrane, and from thence proceed on to the receptacles of the chyle, very evident in a calf; in mankind they are rendered conspicuous

spicuous by blowing air under the membrane, by maceration, or water injected into the arteries.

The *nerves* of the spleen are very small ; from whence it is capable of but little pain, and is very rarely inflamed. They arise from a particular plexus, composed out of the posterior branches of the eighth pair at the stomach, and of certain branches from the large gangliform plexus, which produces the splenic trunk of the intercostal nerve, from whence the branches surround the artery into the spleen.

The fabric of the spleen appears to be much more simple than has been commonly believed. For it is composed, both in us and in calves, altogether of arteries and of veins ; the former of which, after spending themselves in a great number of small branches, are at length thickly subdivided into very soft brush-like bunches, very difficult to fill with injection, terminating in circles ; by which there is a ready passage for liquors into the corresponding veins. These circles, with their parallel branches, form a sort of bunches like a pencil brush, but of a shorter rounder kind ; whence many have mistaken them for glands. Nor does the injection, rightly managed, ever escape from the vessels into the intervals ; nor were any hollow glandules ever discovered by certain observation. Every little arterial trunk, with the smaller twigs that proceed from it, are each of them surrounded by a very fine cellular substance or web-work, in the same manner with the small vessels of all the other viscera, but here rather softer. The whole body of the spleen is outwardly surrounded by a single membrane, which is not very tough, continued from the peritonæum, and joined to the fleshy part of the spleen by a pretty thick cellular texture.

Hence we observe, that the spleen contains more blood in proportion than the other viscera ; since it has no muscles, fat, air-vessels, or excretory ducts, interposed betwixt its blood-vessels. We learn also from observation, that the blood of this part hardly ever
congeals,

congeals, from the abundance of its volatile or bilious salts: but it looks of a dark-brown colour, and may be easily diluted; whence one may compare it almost to the blood of a foetus.

The want of an excretory duct to the spleen, has occasioned the use of it to be doubtful, and controverted throughout all ages of anatomy. To us the fabric itself seems to lead to the following uses; although, perhaps, they do not comprehend all the uses of the spleen. A great quantity of blood is imported to the spleen, and with a slower motion, from the serpentine course and hardness of the artery: but, at the time when the stomach is empty, this blood comes, and is received in a greater quantity by the spleen, not now so much compressed, therein to stagnate, as it would seem plainly from the great proportion of branches to the trunks in this part; to which add, the difficult course or slow circulation which the blood meets with in passing from the spleen through the liver: from hence the frequent scirrhusities of the spleen; and from hence the immense quantity of blood with which the spleen is in every point distended, the like of which we do not see in any other part. Here, then, the almost stagnant blood, fomented with heat, attenuated, and in a manner dissolved by the putrid feces of the adjacent colon, enters thus upon the first steps of a begun putrefaction, as we learn by experiments, both from its colour and consistence. But the greater fluidity of the blood herein proceeds not only from this dissolution, but because all its watery juices that enter by the artery return also again by the vein; for there are no secretory ducts in the spleen.

Moreover, when the stomach is full of food or flatus, the spleen is thereby compressed into a narrower compass, against the ribs and superincumbent diaphragm; by which means the blood, that before was scarce able to creep along through the splenic veins, being now pressed out more plentifully, returns with a
greater

greater celerity towards the liver ; till mixing with the sluggish blood in the trunk of the porta, replenished with the fat or oil of the omentum and mesentery, it dilutes or thins the same, and renders it less apt to stagnate or congeal ; and at the same time it conduces to form a larger secretion of bile at a time when it is most wanted, viz. to flow plentifully to the food now under digestion. The spleen, therefore, seems to prepare the blood, that it may supply a sort of watery juice to the bile ; but such as is probably of a subalkaline nature, and rendered somewhat sharp by the remora of the blood.

Whether is the spleen of a cellular fabric ? Is the blood poured out into those cells so as to stagnate ? or is it diluted with some juice secreted by peculiar glands ? We see nothing of this is demonstrable by anatomy ; nor does the liquor or wax injected ever extravasate into the cellular substance, unless urged with much greater violence than nature ever uses or intended. As to the old question, Whether the spleen brews up an acid to whet or sharpen the stomach ? that opinion has been long discarded, as repugnant to the nature of all the animal juices. If it be asked, Whether the spleen be not an useless mass, as it might seem to be from the little damage an animal sustains after it has been cut out ? we answer, That a robust animal, suffering but little injury from the loss of a part, does not prove it to be useless ; and yet there are examples, after such an experiment has been made, that the liver becomes swelled and disordered, makes a less quantity of bile, and of a darker brown colour ; while the animal is perpetually troubled with flatulencies, gripes, or indigestion : all which are to be ascribed to the vitiated nature of the bile, an obstruction of the liver, and an imperfect or weak digestion ; at the same time they are confirmed by repeated experiments.

§ 16. *Omentum and Appendices Epiploicae.*

Situation, division, and connection of the omentum. The omentum is a large, thin, and fine membranous bag, surrounded on all sides by numerous portions of fat, which accompany and even invest the same number of arteries and veins adhering closely to each other.

The greatest part of it resembles a kind of flat purse, or a sportsman's empty pouch; and is spread more or less on all the small intestines from the stomach to the lower part of the regio umbilicalis. Sometimes it goes down to the lower part of the hypogastrium, and sometimes does not reach beyond the regio-epigastrica. It is commonly plaited or folded in several places, especially between the bands of fat.

It is divided into a superior and inferior, an anterior and posterior, and a right and left portion. The superior portion is in a manner divided into two borders, one of which is fixed along the great curvature or convex side of the arch of the colon, and the other along the great curvature of the stomach. The commissure or union of these two borders on the right side, is fixed to the common ligament or adhesion of the duodenum and colon, and to the contiguous parts of these two intestines. That on the left side is fixed to the longitudinal scissure of the spleen, to the extremity of the pancreas, and to the convex side of the great extremity of the stomach. It is likewise fixed to the membranous ligament which sustains the ductus cholidochus, and connects it to the vena portæ ventralis.

Below these adhesions, the other portions, that is, the anterior, posterior, two lateral and inferior portions, which last is the bottom of the sacculus epiploicus, have commonly no fixed connections, but lie loose between the fore-side of the cavity of the abdomen and the intestines. The anterior and posterior portions are generally called the *laminae* of the omentum; but as that term is

ordinarily employed to express the duplicature of some compound membrane, it would be more convenient to call them *folia*, *alæ*, or some such name.

Structure of the omentum. The membrane of the omentum is, through its whole extent, made up of two extremely thin laminæ joined by a cellular substance; the quantity of which is very considerable along the blood-vessels, which it every where accompanies in broad bands proportioned to the branches and ramification of these vessels. These cellular bands are more or less filled with fat, according to the corpulency of the subject; and for that reason I have called them *bands* or *portions of fat*.

Little omentum. Besides this large membranous bag, which I name the *great omentum*, there is another much smaller, which differs from the large one, not only in size, but also in figure, situation, and connection; and this I name the *little omentum*. This small bag is fixed by its whole circumference, partly to the small curvature of the stomach, and partly to the concave side of the liver before the sinus of the vena portæ, so as to surround and contain the prominent portion of the lobulus.

The little omentum is thinner and more transparent than the other, and its cavity diminishes gradually from the circumference to the bottom, which in some subjects terminates in several small cavities or fossulæ more or less pointed. Its structure is pretty much the same with that of the great omentum, it being composed of two laminæ, with a mixture of the same portions of fat, which are considerably finer than in the other.

We see from this situation of the two omenta, that in the space left between the lower side of the stomach and upper side of the mesocolon, they have a very broad communication with each other; so that if either of them contained in its cavity any fluid, that fluid might readily get between the stomach and mesocolon, and so pass into the other bag; especially when the
stomach

stomach is empty, and consequently its situation easily changed.

Therefore, by means of this interstice between the stomach and mesocolon, the two omenta form one cavity, which opens into the cavity of the abdomen by one common orifice, situated near the commissure on the right side of the great omentum. This orifice is semilunar or semicircular, and formed by the union of two membranous ligaments, whereof one connects the beginning of the duodenum and neck of the vesicula fellis to the liver; the other connects the contiguous portion of the colon to the same viscus, and extends to the pancreas. From thence arises an incurvated border, which surrounds the root of the lobulus, leaving an opening wide enough to admit the end of the finger.

To discover this orifice of the omentum, we need only raise a little the great lobe of the liver, and find out the root of the lobulus, and apply to it a large pipe wrapped round with cotton, wool, or tow, to hinder the regrefs of the air. Then if we blow gradually, the air will inflate the sides of the great omentum, and give it the appearance of a large bladder irregularly divided into several lobes or tubercles by the bands of fat, which appear in this state like so many fræna between the lobes.

To be sure of succeeding in this experiment, the two omenta must be in their natural state, and they must be handled very gently with the fingers first dipped in oil. It succeeds better in young, lean subjects, than in old or fat subjects,

When we touch these membranes with dry fingers, they stick to them so closely as hardly to be separated without being torn, as we see by the reticular holes which appear in those portions of membranes that have been thus handled. In that case it is to no purpose to blow through the natural orifice already mentioned; and it is owing to these small holes that the

membranes of the omentum have been supposed to be naturally reticular.

The membranous laminæ of the little omentum are continuous partly with the external membrane of the liver, partly with that of the stomach, and a little with the membrane that lines the neighbouring portion of the diaphragm. Those of the great omentum are continued partly with the same coat of the stomach, and partly with the external covering of the colon, and consequently with the mesocolon; and they likewise communicate with the covering of the spleen.

We may satisfy ourselves concerning these continuations, by making a small hole in one of the laminæ of the omentum near the stomach, colon, &c. and by blowing into that hole, through a pipe well fitted to it; for the air will gradually insinuate itself under the common coats of these viscera; but if the parts be dry, they must be moistened a little before the experiment is made.

Appendices epiploicæ. The fatty appendices of the colon and rectum are considered by Winslow as a kind of small omenta or appendices epiploicæ. They are situated at different distances along these intestines, being particular elongations of their common or external coat. They are of the same structure with the great omenta; and there is a cellular substance contained in their duplicature, more or less filled with fat, according as the subject is fat or lean.

Next the intestine, each of them forms a broad, thin basis; and they terminate by irregular papillæ, thicker than their bases. These bases are at first disposed longitudinally; then obliquely; and lastly, more or less transversely, especially near the rectum, and upon that intestine.

These appendices are for the most part separated from each other; but some of them which have longitudinal bases communicate together, the vestiges of these communications being very narrow, and not very

prominent. By blowing through a small hole made in one of these appendices, it is inflated like a small irregular bladder, and the air passes under the external coat of the colon or rectum.

Besides these appendices epiploicæ, we observe at different distances along the colon, between the ligamentary band, which lies hid, and one of the other two, that is, on both sides of the adhesion of the mesocolon, several adipose strata, which may likewise be looked upon as appendices of the same nature with the former; but these strata are very seldom observed between the two apparent ligamentary bands of the colon.

Vessels of the omentum. The arteries and veins of the great omentum are branches of the gastricæ, and for that reason go by the name of *gastro-epiploicæ dextræ* and *sinistræ*. The arteries on the right side answer to the hepatic artery, and those on the left side to the splenic; and both communicate with the arteria ventriculi coronaria, and respectively with the arteriæ mesentericæ. The gastro-epiploic veins answer in the same manner of distribution to the vena portæ.

The vessels of the little omentum come chiefly from the coronariæ ventriculi, and those of the appendices and strata are ramifications from the reticular texture of the arteriæ and veins of the colon and rectum.

§ 17. *Secretion of the Bile.*

THE liver, being the largest of all the viscera, fills up a very large part of the abdomen in its upper chamber, above the mesocolon; and is still larger in proportion in the fœtus. It is surrounded on all sides by the neighbouring viscera, and fixed by ligaments in such a way that it is suspended in the body, with a considerable degree of firmness; yet so as to be allowed a considerable liberty to move and be variously agitated, raised and depressed, by the actions of the diaphragm.

This

This large viscus is proportionably supplied with vessels, and of various kinds. For, besides the arteries, it has the vena portarum, which receives all the blood of the stomach, of the intestines and mesentery, of the spleen, omentum, and lastly, of the pancreas, at first into two trunks; the transverse splenic and ascending mesenteric; then into one, which is continued with the mesenterics. This is large, composed of strong membranes, and surrounded with a good deal of cellular substance, derived to it from the mesentery and spleen, dense, short, and adding strength to the membranes; those with which it is furnished being harder than the aorta itself. Intermixed with this cellular substance, are also many of the smaller vessels and hepatic nerves, which all come together under the denomination of a *capsula*. By this the vena portarum is conducted to the liver, and firmly sustained; insomuch, that the branches, being cut, maintain the round lights of their sections. But each branch of this vessel is divided into many others, again divided and subdivided, after the manner of arteries, till they at length produce the smallest capillaries. In this course every branch of the vena portarum is accompanied with a social branch of the hepatic artery, creeping upon the surface of the vein, and the contiguous hepatic ducts, almost in the same manner as the bronchial arteries usually creep along the ramifications of the windpipe in the lungs; while, in the mean time, both the artery and the vein are connected to the branches of the biliary ducts by a thin cellular substance like a spider's web. Some go out of the liver, being divided to the ligaments, and inosculating with the surrounding veins. And the sum of the branches in the vena portarum is always greater than the trunk; whence the lights of all the branches together greatly exceed that of the trunk: from whence follows a great friction or resistance, after the same manner as we observe in the arteries.

But, since the blood is in this manner conveyed through the liver to the branches of the vena portarum, together with the hepatic artery, it must of course be conveyed back again by some other veins: and, therefore, the extreme branches of the vena portarum and hepatic artery inosculate ultimately into other veins, which are *branches of the cava*; which arising from the whole circumference of the liver, run together towards the posterior gibbous part of the liver into branches and trunks, which at last go off into ten or more large vessels. The lesser of these trunks, and greater number of them, pass out through the posterior lobule of the liver, and go to the cava through the *fulcus*, that lies on the right side of the lobule, often completed into a circle by a sort of bridge or production of the liver; from whence they ascend together through the diaphragm towards the left side. Two or three trunks, much larger than the former, are inserted into the same cava, close to the diaphragm, whose veins they often take in by the way. The branches of the vena cava are, in the adult, generally fewer and less than those of the vena portarum; which is an argument that the blood moves quicker, because of the less friction, and of the very collection of the blood into a less light or capacity, by which it is always accelerated when there is a sufficient compressing force. As to any valves at the openings of these branches into the cava, there are none which deserve to be regarded. The trunk of the vena cava, passing through a foramen of the diaphragm, obtusely quadrangular, surrounded and terminated by mere tendons, is thereby rendered not easily changeable: and having surmounted this opening of the diaphragm, it then immediately expands into the right auricle. The smaller veins of the liver creeping about its surface, are sent into the phrenics, renals, and azygos; or at least there is certainly a communication betwixt these and the hepatic veins coming from the portæ.

That

That the blood comes from all parts by the vena portarum to the portæ, is proved by a ligature, by which any vein betwixt these parts and the ligature swells; but the porta itself, above the ligature, grows flaccid and empty. But that it afterwards goes thro' the liver to the cava, appears by anatomical injections, which show open and free anastomoses or communications betwixt the vena portarum and the cava, together with the common nature of the veins going to the cava. Again, the difficult distribution or passage thro' the vena portarum, like to that of an artery, together with its remoteness from the heart, and the oily or sluggish nature of the blood itself, occasion it to stagnate, accumulate, and form scirrhus swellings in no part oftener than the liver. But this danger is diminished by the motion of the adjacent muscles, and by the respiration; as it is increased by inactivity, with sour and viscid aliments. But, hitherto, we have been speaking of the adult liver, in which both the umbilical vein and the ductus venosus are empty and closed up, although they continue to cohere with the left branch of the vena portarum.

The *nerves* of the liver are rather numerous than large; hence, when wounded or inflamed, it is capable of no very great pain.

The *lymphatic vessels* of the liver are numerous, arising from all sides, and passing into the thoracic duct.

The interior fabric of the liver is more obscure. Through the whole substance of the liver go bundles of biliary vessels, of branches of the vena portarum, and of the hepatic artery. Each vessel has both its proper cellular texture surrounding it, and similar ligaments, by which it is tied to its fellow vessels; and, lastly, the whole bundle has its cellular texture placed round it. The branches of the vena cava lie on the outside of the rest, being less accurately received into the same bundle. Lastly, the ultimate small branches of the vena portarum, cava, and hepatic artery, together

ther with the bilious ducts, are united together by means of the cellular substance, into a sort of mulberry-like bunches, of an hexagonal shape, surrounded with a lax cellular texture. In these bunches, likewise, there are mutual anastomoses betwixt the portal branches and hepatic artery, with the roots of the vena cava on one side, and the first organs of the *pori biliarii* of the liver on the other side; which last demonstrate their inosculation by anatomical injections; for liquors injected by the vena portarum return again through the *porus cholidochus*.

Many eminent anatomists have taught, that the fore-mentioned bunches are hollow, having arteries and veins spread upon their external surface, and deposite the bile into their cavity, after it has been secreted from the branches of the vena portarum. For this they allege arguments taken from the comparative anatomy of brutes, whose liver is made up of more round and definite bunches; and from those diseases which demonstrate cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this they might have added the thick sluggish nature of the bile itself, by which it is related to mucus, and the analogy of the follicles of the gall-bladder.

But greater accuracy in anatomy will not allow any follicles into which the small secretory vessels open; for such would intercept the course of anatomical injections, and give us the appearance of knots, intermediate betwixt the secretory vessels and the biliary pores, which we have never yet been able to see; for the wax flows immediately, without any interruption or effusion, into a cavity in a continued thread from the vena portarum into the biliary ducts. But, again, a follicular or glandular fabric is not allowable in the liver, from the great length of the biliary ducts. For all follicles deposite their contents into some space immediately adjacent; and are unfit to convey their secreted fluid to
any

any length of course, as they destroy so great a part of the velocity received from the arteries. Lastly, the very common pressure which we must suppose to be on these bunches of kernels, would so crush them, that no assistance could from thence be brought to promote the motion of the excretory ducts. Concretions and hydatids are formed in the cellular substance; and, lastly, the bile, when first secreted, is sufficiently fluid.

Haller is persuaded that no bile is separated from the hepatic artery; because the peculiar structure of the vena portarum would be useless if it secreted nothing. Its office in secretion appears plainly by the continuations of its branches with the biliary ducts, in a manner more evident than that of the artery: but it appears by experiments, also, that the biliary secretion continues to be carried on after the hepatic artery is tied; add to this the largeness of the biliary ducts, in proportion to so small an artery, with the peculiar nature of the blood collected in the vena portarum, so extremely well fitted for the formation of the bile. But in the blood of the hepatic artery, says Haller, we can find nothing peculiarly fit for the secretion of bile, or analogous to its nature.

Since, therefore, the vena portarum conveys the blood ready charged with biliary matter, fit to be secreted in the least acini, and from thence there is an open free passage, without any intermediate follicles, from the ultimate branches of the vena portarum into the beginning roots of the biliary ducts, and that the humours driven into the vena portarum may easily choose this passage, the bile will be expelled from thence by the force of the blood urging behind, as well as by the auxiliary force of the diaphragm pressing the liver against the rest of the viscera in the abdomen when very full; and again, contracted in expiration, it will be forced into the larger branches, and lastly into two trunks of the larger biliary duct of the liver; which trunks meet together in one upon the vena portarum,

in the transverse fossa of the liver, near the anonymous lobule.

The fabric of this duct is made up like that of the intestines. But there is here no muscular fabric apparent. From experiments it appears to be endowed with a moderate degree of irritability. That it is vastly dilatable, is shown from diseases. The same seem also to show that this duct is endowed with a very sharp sensation.

The hepatic duct, thus formed, goes on upon the vena portarum, more to the right than the artery, towards the pancreas; and then descending obliquely, covered by some part of that gland, it goes to the lower part of the second flexure of the duodenum, and is inserted backward about four or five inches from the pylorus, through an oblique oblong sinus made by the pancreatic duct, into which it opens by a narrow orifice. The said sinus runs a great way through the second cellular coat of the duodenum obliquely downward; then it perforates the nervous coat, and goes on again obliquely betwixt it and the villous tunic; and, lastly, it opens into a protuberant long wrinkle of the duodenum. Thus there is almost the length of an inch taken up betwixt the first insertion and the egress of this duct through the coats of the duodenum, by a sinus which surrounds and receives the ductus cholidochus, in such a manner, that when the coats of this intestine are distended by flatus, or closely contracted by a more violent peristaltic motion, the opening of the duct must be consequently compressed or shut; but when the duodenum is relaxed and moderately empty, the bile then has a free exit. Any regurgitation from the duodenum is hindered by this obliquity and wrinkling of the duct, easily pressed together, or closed and joined with a quick succession of fresh bile descending perpendicularly from the liver. Nor does wind inflated into the intestine find any passage into the duct.

But, in the portæ themselves, this common duct receives

ceives another less canal of the same kind, which lies for a good way parallel with itself from the gall-bladder, making its insertion in a very acute angle; and this, which is called the cystic duct, from its origin, is sometimes first increased by another small duct from the hepatic before its common insertion. This duct is formed by the gall-bladder as a peculiar receptacle for the bile given to most animals; but is absent in some, especially those of a swifter foot, and perhaps only in such of these as are herbivorous: it is placed in an excavation of the right lobe of the liver, to the right side of the anonymous lobule, in such a manner, that in infants or children it lies wholly within the edge of the liver, but in adults projects considerably beyond, lying upon the intestinum colon. Its situation is almost transverse from the fore to the back parts; its neck ascends a little upwards.

The figure of the gall-bladder is variable, but in general like that of a pear, terminated in its fore-part by an obtuse hemispherical end, which is impervious, gradually diminishing backward; the neck or tip of this truncated cone being inflected upwards against itself once or twice, and tied together by the cellular substance belonging to it, makes then another small flexure upward, and begins the cystic duct; which from thence goes on towards the left side of the hepatic duct. Within this duct there are many protuberant wrinkles, formed by the numerous cellular bridles which tie them together: and these wrinkles, conjunctly in the dry gall-bladder, represent a kind of spiral valve; but being altogether soft and alternate in a living person, they do not stop, only lessen the course of the bile, as we are assured from experiments, by pressing the gall-bladder, and by inflations. Besides, it is reticulated like the gall-bladder itself.

The coats of the gall-bladder are like those of the intestines, only the second coat has sometimes splendid fibres, chiefly longitudinal; but some obliquely intersecting

setting each other in various directions ; at other times it has none at all : so that we may doubt of its muscular nature, especially as the irritability of the gall-bladder is slow and obscure. The inner coat differs from that in the intestine, in being reticulated and full of cells.

The generality of animals, between their gall-bladder and liver, or between the ducts coming from both, have, besides, some peculiar openings in the gall-bladder, into which some ducts originating from the liver, or the hepatic biliary duct, discharge their contents. In mankind these ducts have not been shown by any certain experiment ; and the gall-bladder is easily loosed from the liver, without a drop of bile distilling either from it or from the liver. There is also a thin water in the bladder as often as the cystic duct is obstructed.

The bile flows both out of the bladder and liver, according to its nature, as long as there is no impediment in its way ; so that both ducts swell when that passage is obstructed, and the cystic lies in a straight line with the cholidochus. Nor is it credible that all the bile should be diverted into the gall-bladder before it flows into the duodenum. There is not a perpetual obstacle which hinders the afflux, and peculiarly resists the hepatic bile, and admits the cystic ; the passage into the ductus cholidochus is larger and straighter, the ductus cysticus much less than the hepatic, nor is that duct so well formed for receiving all the bile ; the cholidochus being much larger than the cystic duct, cannot therefore be made only for the reception of its bile. There are many animals in which the hepatic duct discharges its contents into the intestine without any communication with the cystic. In living animals, even when the cystic duct is free, the bile appears to descend into the duodenum with a perpetual current. That the quantity is very considerable, appears from the magnitude of the secretory organ, and the excretory duct, so many times larger than the salival ones ;
from

from diseases, in which four ounces of the cystic bile only have flowed out duly through an ulcer of the side. But the hepatic bile goes into the bladder, as often as there is any obstruction in the duodenal sinus, from flatus or any other cause compressing the exit of the ductus cholidochus. Accordingly, we find it extremely full, whenever the common biliary duct is obstructed or compressed by some scirrhus tumor, whence the gall-bladder is sometimes enlarged beyond all belief; and if the cystic duct be tied, it swells betwixt the ligature and hepatic duct; and in living animals, the hepatic bile visibly distils into the wounded gall-bladder, even to the naked eye. The retrograde angle, or direction of this duct, is not repugnant to such a course of the bile: for a very slight pressure urges it from the liver into the gall-bladder; and even wind may be easily drove the same way, more especially if the duodenum be first inflated. Nor does there seem to be any sort of bile separated by the gall-bladder itself. Whenever the cystic duct is obstructed by a small stone, or a ligature made upon it, we find nothing separated into the gall-bladder more than the exhaling moisture, and a small quantity of insipid mucus secreted from the follicles. In many animals, we meet with no appearance of any gall-bladder, when at the same time there is a plentiful flux of strong well prepared and salutary bile discharged into their intestines. Again, it does not seem probable, that the cystic branch of the vena portarum can separate bile into the gall-bladder; for that vein in itself is a mere recondutory vessel: nor can any be separated from the hepatic artery: for it must be vastly beyond probability, that such a strong bile as that of the gall-bladder should be separated from a milder blood than the more soft hepatic bile prepared from the blood which is most fit for that purpose.

Lastly, the bile flows also from the gall-bladder to the liver, and at length returns into the blood when
its

its passage into the intestines is totally intercepted, sometimes also from a cause latent in the nerves. This passage or absorption of the bile into the system is pernicious, and is the occasion of jaundice; which, when the offending stones or concretions are removed, is cured by the bile's free course into the duodenum being restored.

Therefore a portion of the hepatic bile being received into the gall-bladder, there stagnates, only a little shaken by respiration; and there, by degrees, exhales its thinner parts, which, as we see, filtrate thro' and largely penetrate the adjacent membranes. The remainder, as being a fluid of an oily subalkaline nature, digesting in a warm place, grows sharp, rancid, more thick, bitter, and of a higher colour: for this is all the difference betwixt the cystic and hepatic bile; which last we find weaker, less bitter, lighter coloured, and of a thinner consistence, while it remains within its proper hepatic ducts. That this difference betwixt them proceeds only from stagnation, appears from such animals as have only a larger porus hepaticus, instead of a gall-bladder; for here we find the bile, which stagnates in the larger hepatic pore, is considerably more bitter than that in the smaller pores of the liver; as for example, in the elephant. But the gall-bladder gives this particular advantage, that it receives the bile when the stomach, being empty, has no call for it, that afterwards it may be able to return it in greater plenty, when we principally want it for the digestion of the aliments now flowing in great quantity into the duodenum. This flow of the bile is quicker in proportion through the cystic duct, as the section of that duct is less than the section of the gall-bladder.

The gall-bladder, indeed, hardly touches the stomach, but the beginning of the descending duodenum. But when the stomach is extremely distended, and in a very full abdomen, it makes a considerable pressure both upon the liver and duodenum; by which the gall-bladder

bladder is urged, and its bile expressed. Thus the bile flows through a free passage from the gall-bladder into the common duct and the duodenum: and this it does more easily in persons lying on their back; in which posture the gall-bladder is inverted, with its bottom upward. Hence it is that the gall-bladder becomes so full and turgid after fasting. The expulsive force of the bile is but little more than that of the pressure received from the stomach and diaphragm; for as to any muscular force residing in the fibres of the proper membrane, which may be thought to contract the gall-bladder, it must be very weak and inconsiderable.

The hepatic bile is always bitter, but the cystic is more so; always viscid; of a full yellow colour, with a tincture of green; miscible, by triture, either with water, oil, or vinous spirits; coagulable by mineral acid liquors; dissoluble by alkalies, especially the volatile kinds; and extremely well adapted to dissolve oily, resinous, or gummy substances; quickly putrefying, and by putrefaction spontaneously degenerating to a musk-like odour. Its chemical analysis, and experiments of mixture with various substances, demonstrate, that it contains a large portion of water, and a considerable quantity of inflammable oil, which, in stones of a gall-bladder, appears very evidently. The bile, therefore, is a natural soap; but of that sort which is made from a volatile saline lixivium, mixed with oil; and has its water along with it. This, therefore, being intermixed with the aliment, reduced to a pulp, and slowly expressed from the stomach by the peristaltic force of the duodenum and pressure of the abdominal muscles, incorporates them all together; and the acid or acescent qualities of the food are in some measure thus subdued, the curd of milk is again dissolved by it into a liquid, and the whole mass of aliment inclined more to a putrid alkalescent disposition: it dissolves the oily matters, so that they may freely incorporate with the watery parts, and make up an uniform mass of chyle to enter

enter the lacteals; the surrounding mucous in the intestines is hereby absterged and attenuated, and their peristaltic motion is excited by its acrimony; all which offices are confirmed, by observing the contrary effects from a want or defect of the bile. Nor is the hepatic bile sufficient to excite the necessary motion of the intestines, if the cystic is wanting; both which are of so much use and importance to the animal, that we find, by experiment, even the strongest will perish in a few days, if the flux of bile to the intestines be intercepted, by wounding the gall-bladder.

Thus it slowly descends along with the alimentary mass; and having spent its force, or changed its bitterness by putrefaction, most of it is afterwards excluded together with the feces; but probably some of the more subtile, watery, and less bitter parts, are again taken up by the absorbents. It returns the less into the stomach, because of the ascent of the duodenum, which goes under the stomach, with the resistance it meets with from the valvula pylori, and the advancement of the new chyle which the stomach adds to the former: in man, however, it frequently enters; and always in birds. The bile is of a sweet soft nature in the foetus; for in them the blood seems not sufficiently charged for its secretion to supply putrid alkaline vapours to the liver, nor are there any oily or fat substances absorbed from the intestines. As the bile is a viscid fluid, and thickens by inactivity of body in fat animals, and in us from the same causes, especially when the blood moves languid from grief; so it easily coagulates into an hard, somewhat resinous, and often stony substance, insomuch that stones of the gall are much more frequent than those of the urinary bladder, as we are taught by experiments. Its use is manifest, as, being triturated with the aliments, it dissolves oil, resists acidity, and thus stimulates the intestines to contraction.

The use of the liver, besides secreting the bile, is manifest in the foetus. It seems to transmit the blood
brought

brought back from the placenta, and to break its force. Even in an adult person it has the same use though less manifest, namely, to retard the return of the blood coming back from the viscera appointed for preparing the chyle.

§ 18. *Renes et Ureteres.*

Situation, figure, and division of the kidneys. THE kidneys are two pretty solid glandular bodies, situated in the posterior part of the cavity of the abdomen, on each side of the lumbar vertebræ, between the last false ribs and os ilium. The right kidney lies under the great lobe of the liver; and is consequently lower than the left, which lies under the spleen.

The figure of the kidneys resembles that of a large bean, their circumference being convex on one side, and concave on the other. The concave side is turned to the vertebræ, and the convex side the opposite way. Their length answers to the distance between the last false rib and os ilium; they are about half as broad as long, and half as thick as broad.

In each kidney we observe a fore and back side, an upper and lower extremity, a great and small curvature, and a convexity and concavity.

The back-side is broader than the fore-side; and the upper extremity is a little broader and more incurvated than the lower. The depression in the small curvature is oblong and uneven, resembling a sinus, furrounded by several tubercles; and as it is turned a little toward the fore-side, this side is something narrower than the other.

Blood-vessels of the kidneys. The descending aorta and inferior vena cava lie between the kidneys, pretty close to the bodies of the vertebræ and to each other; the artery being on the left hand, the vein on the right. The renal artery comes commonly from the side of the aorta under the superior mesenteric artery: that of the
left

left side has its origin a little higher and further back than that of the right side; and both having run over almost at right angles, enter the sinus of the kidney, and divide into many branches, which subdivide into many others still smaller. The renal veins have less variety than the arteries. It is seldom we find more than one on each. From each kidney several branches come out, which soon unite to form a trunk, which ends in the vena cava. These vessels were by the ancients termed the *emulgent arteries and veins*, but they frequently go under the name of *arteriæ et venæ renales*.

The artery and vein are not of an equal length, and the difference depends on the situation of the aorta and vena cava: for the left renal artery is shorter than the right, because the aorta lies nearest the left kidney; and the left renal vein is longer than the right, because the vena cava lies furthest from the left kidney.

These vessels are likewise disposed in such a manner, as that the veins lie more anteriorly than the arteries; because the aorta lies close to the spina dorsi; whereas the vena cava, which perforates the diaphragm at some distance from the vertebræ, does not join them till after it has given off the renal veins.

Nerves of the kidneys. Each artery is surrounded by a nervous net-work, called *plexus renalis*; which furnishes a great number of filaments to the kidneys, that come partly from the semilunar ganglions of the two great sympathetic nerves, and partly from the plexus hepaticus and splenicus. This renal plexus sends likewise some filaments round the renal veins.

Coats of the kidneys. The kidneys are surrounded by a very loose membranous and cellular covering, called *membrana adiposa*; because, in fat persons, the cells of this substance are filled with fat. This was for a long time impertinently taken for a duplicature of the peritonæum; the true membranous lamina of which covers only the foreside of the kidneys; and consequently they

lie

lie without the peritonæum, because the portion of that membrane that covers them cannot be looked upon as an entire coat: so that the only common coat they have is the cellular substance, which likewise invests the renal arteries and veins in form of a vagina.

The proper coat or membrane of the kidneys is strong and dense, and adheres very closely to their surface; for it penetrates every where by numerous elongations into their substance, from which it cannot be separated without tearing these.

The external surface of this lamina is very smooth, polished, and glistening; and it renders the whole surface of the kidney very even and uniform in adults. In children, this convex surface is in a manner divided into several lobes and tubercles, almost as in oxen and calves; and in grown persons we sometimes observe the same inequalities.

The blood-vessels having entered the kidneys, are ramified every way; and these ramifications send out other capillary rami, which go all the way to the surface, where they appear like irregular stars, and furnish the proper membrane of the kidneys. Sometimes these two ramifications penetrate to the membrana adiposa, and communicate there with the arteriæ and venæ adiposæ.

The proper membrane having surrounded the kidney all the way to the sinus, joins the vessels at that place, and accompanies all their ramifications through the body of the kidney in form of a vagina or capsule, and likewise contributes in part to form the pelvis and calices or infundibula; of which hereafter.

We sometimes observe a considerable vessel to go in or come out from the convex surface of the kidney; but this is not common: and in that case there is a depression, by which the proper membrane enters, and communicates with that portion which goes in by the sinus.

The tunica adiposa, or common coat, which likewise

invests the great vessels to their entry into the kidneys, does not seem to accompany them any further, but terminates at the sinus, in the interstices between the ramifications.

Structure of the kidneys. We may distinguish three kinds of substances in the kidney; an exterior substance, which is thick, granulated, and in a manner cortical; a middle substance, which is medullary and radiated, called *striata, sulcata, or tubularis*, because it seems to be made up of radiated tubes; and an inner substance, which is only a continuation of the second, and terminates on the inside by papillæ; for which reason it goes under the name of *papillaris*.

These three substances may be seen distinctly in a kidney cut into two equal parts through the great curvature. The cortical substance may be observed round the whole circumference; and, by the microscope, we perceive it to be of a spongy, granulated, and waving texture, all its parts adhering together in a radiated manner. Its colour is a bright whitish grey.

By fine anatomical injections and inflammations, we discover an infinity of small capillary vessels, which run in various directions between and round the different portions of this substance; and, by the help of a microscope, we see likewise great numbers of small red corpuscles more or less round, and disposed almost like bunches of currants. These small corpuscles are perhaps only the extremities of vessels, filled either with blood or with a coloured injection.

The other two substances, that is, the medullary or striated, and the papillary, are really but one and the same mass, of a more reddish colour; the convex side of which rises at several places into narrow tubercles, lodged in the same number of cavities or depressions. The radiated striæ are afterwards continued to the papillary portion; and the papillæ form in some measure so many centres of these radii, opposite to the tubercles.

The medullary substance is likewise distinguished from

from the cortical, by the arterial and venal arches, which send capillary ramifications on all hands; and its colour is more or less red.

The papillæ, which are only a continuation of the medullary substance, as has been said, are often a little paler than that substance. They are ten or twelve in number, very distinct from each other, resembling the same number of cones, with very broad bases and obtuse apices.

At the point of each papilla we see, even without a microscope, in a small depression, several very small holes, through which little drops may be perceived to run when the papillæ are compressed. These are little drops of urine; which being filtered, partly in the cortical, partly in the medullary or tubular substance, do afterwards pass through the substance of the papillæ, and are discharged by these orifices.

The pelvis of the kidneys. Each papilla lies in a kind of membranous calix or infundibulum, which opens into a common cavity, called the *pelvis*. This pelvis is membranous, being of the same structure with the calices, of which it is a continuation; and its cavity in man is not uniform, but distinguished into three portions, each of which contains a certain number of infundibula or calices, together with the papillæ which lie therein; and sometimes we find two or three papillæ in the same infundibulum.

At the place where these infundibula surround the bases of the papillæ, they send productions into the medullary or radiated substance of the kidney, which accompany the blood-vessels, and serve for capsules or vaginæ to all the vascular arches, both arterial and venal, and to their different ramifications, quite thro' the cortical substance, and as far as the surface of the kidney.

Ureters. After the infundibula have contracted in a conical form round the apices of the papillæ, each of them forms a small short tube or gullet, which uni-

ting at different distances along the bottom of the sinus of the kidney, form three large tubes which go out from the sinus, in an oblique direction from above downwards, and immediately afterwards unite into one trunk.

This trunk becomes a very long canal, called the *ureter*. In men, the three tubes supply the place of what is called the *pelvis* in brutes, and might more properly be called the *roots* or *branches* of the ureters than the *pelvis*; which name would agree best to the trunk, as being larger than the rest of the ureter. The ureters are commonly two in number, one for each kidney; but sometimes there are more than two.

The situation of the trunk, and of the roots and branches of each ureter, with respect to the renal artery and vein, is in the following manner: The artery is in the upper part of the sinus, and partly before the vein. The vein is about the middle, and between the artery and ureter. The ureter is in the lower part, a little behind the vein, and it is partly surrounded by one branch of the artery.

This disposition appears plainer near the anterior than near the posterior side of the kidney, because this last is broader than the former; and we likewise see there the three branches of the ureter; of which the uppermost is the longest, and the lowest is the shortest, because of their oblique direction downward.

From this description, we see, that in the human kidney there is no other common or uniform *pelvis*, but the trunk or head of the ureter, and the three great branches. To have a true idea of their disposition, we must imagine that the ureter enters the kidney by the lower part of the oblong sinus; that it increases gradually in breadth as it advances; and that it is divided into three branches, before it enters the substance of the kidney.

One of these branches may be reckoned a direct continuation of the ureter, and it is longer than the rest, being

being extended from the lower to the upper part of the sinus ; and it may be found without much preparation. The other two branches are shorter, and cannot be well discovered without an artificial separation. The angles between these branches at their bases, or at the head of the ureter, are not pointed as those of other ramifications, but formed by a round incurvation, which is generally surrounded by fat.

These first branches of the ureters produce other small branches at the bottom of the sinus, which are disposed in pairs. These small collateral branches extend in breadth, and form the infundibula or calices, in which the papillæ are lodged ; the great circumference of which produces, in the substance of the kidney, the different vaginae of the vascular arches and of their ramifications. The internal lamina of the kidney is continued round these vaginae ; and the external lamina is expanded round the first branches, round the trunk, and round all the rest of the ureter.

If the trunk of the ureter be split on that side which is next the vertebræ, and this section be continued to the extremity of the superior branch, we may observe, immediately above the trunk, two holes lying near each other, which are the orifices of the small collateral branches and gullets of the infundibula. A little above these holes, there are other two very much like them, and so on all the way to the extremity of the superior branch, which terminates likewise by these gullets of the infundibula ; and in each of these gullets we may observe at least the apex of one papilla.

A section begun on the convex surface of the kidney, and carried from thence to the trunk of the ureter, discovers the extent of the papillæ very plainly, and likewise the infundibula, their gullets, &c. ; but it will be difficult to give beginners a just idea of the structure of these parts without the other section.

The ureters run down obliquely, and with a very small degree of inflexion, from the kidneys to the lateral

ral parts of the inner or anterior side of the os sacrum ; and passing between the rectum and bladder, they terminate in the last of these viscera, in the manner that shall be explained hereafter.

They are composed of three proper coats ; the first of which, that surrounds the rest, is of a whitish colour, and of a very compact filamentary texture, being stretched with difficulty, and appearing like a filamentary substance degenerated. The next coat is of a reddish colour, stronger than the first, and is composed of muscular fibres, although this has been doubted by some authors.

The innermost coat is in some measure ligamentary, and lined by a very fine membrane, which covers a very delicate reticular texture of vessels, and is moistened all over by a mucilaginous liquor.

Besides these proper coats, the ureters are invested by the cellular substance of the peritonæum ; the membranous lamina of which covers likewise about two thirds of their circumference, sometimes more, sometimes less, but never surrounds them entirely : so that when they are examined in their natural situation, they appear like ropes lying behind the peritonæum, and jutting out more or less toward the cavity of the abdomen, together with that portion of the peritonæum which covers them.

All that has been said about the structure of the ureters, pelvis, arches, striæ, fossulæ, and holes at the apex of the papillæ, appears most distinctly when these parts are examined in clear water.

§ 19. *Glandulæ renales, vulgo Capsulæ atrabiliaria:*

Situation, figure, and size of the renal glands. Immediately above each kidney lies a glandular body, called by the ancients *capsulæ atrabiliaria* ; by others, *capsulæ renales*, *renes succenturiati*, and *glandulæ renales* ; and they might be properly enough termed *glandulæ*

supra

supra renales. They are situated on the upper extremity of each kidney a little obliquely, that is, more toward the inner edge and sinus of the kidney than toward the outer convex edge.

Each gland is an oblong body with three sides, three edges, and two points, like an irregular crescent with its great or convex edge sharp, and the small concave edge broad. Its length is about two-thirds of the greatest breadth of the kidney, and the breadth of its middle portion is about one-third of its extent between the two extremities, sometimes more, sometimes less. Its colour is a dark yellow.

It has one anterior, one posterior, and one lower side, which last may be termed the *basis*; and it has one upper, and two lower edges, whereof one is anterior, the other posterior. The upper edge may be called the *crista*, and the two lower edges the *labia*. One of its extremities is internal, or turned inward toward the sinus of the kidney; the other is external, or turned outward toward the gibbous part of the kidney. The figure of this glandular body may likewise be compared to that of a single cock's-comb, or to the top of an helmet.

Structure of the renal glands. The surface of these glands is uneven; the fore-side is the broadest, and the lower side or basis the narrowest. Along the middle of the anterior side, a ridge runs from the edge of the inner extremity a little above the basis, to the point of the other extremity, and divides this side into two equal parts, like the middle rib of the leaf of a tree, and on the lower side, under the basis, there is a kind of raphe or future.

The arteries of these glands come from the arteriæ renales, and diaphragmaticæ, and likewise from the aorta, from the arteria cæliaca, &c. These vessels are termed the *capsular arteries*; and as they enter the glands, they seem to be invested by a vagina. They are not always derived from the same sources, neither

is their number the same in all subjects : and there is commonly a pretty large vein which runs along the ridge. One principal vein returns the blood from each of these glands ; the right goes into the vena cava, the left passes into the renal vein. The nerves on each side are furnished by the neighbouring semilunar ganglion, and by the renal plexus which depends on it.

In the inside of these capsulæ, there is a narrow triangular cavity, the surface of which is full of short, strong villi of a yellowish colour ; but in children it is reddish, and of a dark brown in aged people. The sides of this cavity are connected by a great number of filaments ; and they appear to be wholly glandular, that is, to be filled with very fine small folliculous corpuscles. Along the top of the gland these sides touch each other immediately.

In opening this cavity, we find a granulated or follicular substance, which fills it almost entirely ; and the blood-vessels are distributed on this substance, as well as on the sides of the cavity. If the section be begun at the great extremity of the capsula, and be continued through the upper edge, and if the lateral portions be afterwards separated, the glandular body appears like a kind of crista, raised from the middle of the bottom of the cavity.

This glandular body or nucleus adheres more closely to the bottom or basis of the cavity, than to the two sides, especially near the great extremity ; but yet it may be separated both from the basis and sides, being connected to them by a great number of small filaments. It adheres least to the basis near the small extremity.

The capsular vein, which comes ordinarily from the vena renalis, is much larger than the arteries ; and it communicates with the inside of the capsula much in the same manner as the vena splenica with the cells of the spleen, for it may be inflated by blowing into any part
of

of the capsular cavity, and the air likewise passes into the vena renalis, &c.

This cavity contains an unctuous viscid liquor, of a yellowish red colour, which, with age, changes gradually into a yellowish purple, a dark yellow, and a black yellow: sometimes it is perfectly black; but even then if it be spread thin on a large surface, it appears yellow. It is sometimes found not only reddish, but mixed with real blood.

The uses of these renal glands have not as yet been discovered; and all that we know about the liquor contained in them is, that it has somewhat the appearance of the bile. They are very large in the foetus, and diminish in adults. These two phænomena deserve our attention.

They lie sometimes directly on the top of the kidneys, but seldom, if ever, on the gibbous part. The gland on the right side is partly connected to the diaphragm, under and very near the adhesion of the great lobe of the liver to that muscle. That on the left side adheres to the diaphragm below the spleen; and both these connections are confined to the contiguous portions of the inferior muscle of the diaphragm. They are involved, together with the kidneys, in the membrana adiposa, of which a very thin portion insinuates itself between the kidneys and glands, and also between them and the diaphragm; so that they adhere to both by the intervention of the cellular substance, which in some subjects contains a stratum of fat.

The venal ridge already mentioned, sinks so deep into the fore-side in some subjects, that the upper part of this side appears to be separated from the lower; but this is seen most distinctly when the capsula is examined in clear water.

When the capsular vein is opened lengthwise with the point of a lancet, we discover in it a great many small holes, many of which are only the orifices of the rami of the vein, others are simple holes; and it is perhaps

perhaps through these that the air passes into the gland, as already mentioned.

On the outer surface of these capsulæ we observe a very thin, distinct coat, separate from the cellular substance that surrounds them. Sometimes this coat is raised by an uneven stratum of fat, which makes it appear granulated; and, for the same reason, the capsulæ are of a pale colour like a corpus adiposum.

The liquor contained in them appears sometimes, in the foetus, and in young children, of a bluish colour inclined to red.

To be able to discover the uses of these capsulæ, we must not only attend to the two circumstances already mentioned, but also to their external conformation, which is commonly more regular in the foetus and in children than in adults and old people. We must likewise consider the consistence and solidity of their substance; which is greater before birth, and in childhood, than in advanced old age; in which they are often very flaccid, and very much decayed; and this perhaps may be the reason why the figures given of these glands, taken out of their membrana adiposa, are so very irregular and different from others.

C H A P. IV.

Of the PELVIS.§ 1. *Vesica Urinaria.**Situation, figure, and division of the bladder.*

THE bladder is a kind of membranous and fleshy pouch or bottle, capable of dilatation and contraction, situated in the lower part of the abdomen immediately behind the symphysis of the ossa pubis, and opposite to the beginning of the intestinum rectum. The figure of it is nearly that of a short oval. It is broader on the fore and back sides than on the lateral parts; rounder above than below, when empty; and broader below than above, when full.

It is divided into the body, neck, and bottom; into an anterior, posterior, and two lateral parts. The upper part is termed the *fundus*, or *bottom*; and the neck is a portion of the lower part, which is contracted like the gullet of some vessels.

Structure of the bladder. The bladder is made up of several coats, almost like the stomach. That part of the external coat which covers the upper, posterior, and lateral sides of the bladder, is the true lamina or membrane of the peritonæum; and the rest of it is surrounded by a cellular substance, by the intervention of which, the peritonæum is connected to the muscular coat.

The proper coats are three in number; one muscular, one cellular, and an internal smooth one commonly called *villous coat*. The muscular coat is composed of several strata of fleshy fibres; the outermost of which are mostly longitudinal; the next to these are more inclined

clined toward each hand ; and the innermost more and more oblique ; and they become at length almost, transverse. All these fibres intersect each other in various manners ; and they are connected together by a fine cellular substance, and may be separated by inflating that substance.

Round the neck of the bladder the muscular fibres are closely connected, and form what has been called *sphincter vesicæ*. But this part is not a distinct muscle, nor is its action distinct from the rest of the muscular coat.

The cellular coat is nearly of the same structure with what is called the *tunica nervosa* of the stomach.

The internal coat is something granulated and glandular, says Winslow ; but later anatomists deny the existence of glands here. A mucilaginous serum is continually discharged through it, which moistens the inner surface of the bladder, and defends it against the acrimony of the urine. It appears sometimes altogether uneven on the inner side, being full of eminences and irregular rugæ when empty and in its natural state of contraction. These inequalities disappear when the bladder is full, or when it is artificially distended by air, or by injecting any liquid.

Urachus. At the top of the bladder above the symphysis of the ossa pubis, we observe a ligamentary rope, which runs up between the peritonæum and the linea alba of the abdomen, all the way to the navel, diminishing gradually in thickness as it ascends. This rope in the fœtus is in part a production of the inner coats of the bladder, which production is termed *urachus*.

Arteriæ umbilicales. This rope is composed likewise of two other ligamentary elongations, which are the extremities of the umbilical arteries. These arteries come from the hypogastricæ, run up by the sides of the bladder, and remain hollow and filled with blood, even in adults, as high as the middle of the bladder, through all which space they likewise send off ramifications,

tions. Afterwards they lose their cavity, and become ligamentary as they ascend. At the upper part of the bladder they approach each other; and joining the urachus, form that rope, which may be termed the *superior ligament of the bladder*.

The external fibres of the muscular coat are more numerous than the internal; and the most longitudinal anterior fibres form a kind of incurvation round the urachus at the top of the bladder, much like that of one of the fleshy portions which surround the superior orifice of the stomach and lower extremity of the œsophagus. This incurvation passes behind the urachus.

The portion of the peritonæum, which covers the posterior convex side of the bladder, forms a very prominent transverse fold, when the bladder is contracted, which disappears when the bladder is extended. This fold surrounds the posterior half of the bladder, and its two extremities are elongated toward each side; by which elongations a kind of lateral ligaments of the body of the bladder are formed, which are more considerable in children than in adults. Besides these, the bladder has other two ligaments, which are fixed at their fore-part to the upper and inner side of the ossa pubis, near the symphysis of these two bones; from whence they run back, becoming gradually broader, to be fixed to the sides of the bladder; or, as Sabatier describes them, as the inferior anterior ligaments of the bladder.

The lower part of the bladder, which deserves the name of *fundus* much better than the upper part, is perforated by three openings, one anterior, and two posterior. The anterior opening is formed by an elongation of all the proper coats, in form of a gullet, turned much in the same manner with the inner orifice of the rostrum of the head of an alembic. This elongation is called the *neck of the bladder*, the description of which belongs to that of the parts of generation in men.

The

The other two openings in the true fundus of the bladder, are formed by the ureters, which in their course downward, already described, run behind the spermatic vessels, and then behind the lower part of the bladder, approaching each other. Each ureter lies between the umbilical artery and vas deferens of the same side; the artery lying on the outside of the ureter, and the vas deferens on the inside.

Afterwards they get between the vasa deferentia and the bladder, crossing these canals: and then, at about a finger's breadth from each other, they begin to pierce the coats of the bladder. They run a little way between the muscular and nervous coats, and open into the bladder obliquely, something nearer each other than when they first entered in coats.

The orifices of the ureters in the bladder are something oval and narrower than the cavity of the ureters immediately above them. The edge of these orifices is very thin, and seems to be formed merely by the union of the internal coat of the bladder with that of the ureters.

Blood-vessels and nerves of the bladder. The arteries of the bladder are furnished by the hypogastricæ or iliacæ internæ, being rami of the arteria sciatica, epigastrica, and umbilicalis on each side. The veins return to the internal iliac veins.

The nerves of the bladder come from the crurales, and also from the sympathetici maximi, by means of their communication with the crurales. It has likewise some nerves from the plexus mesentericus inferior.

Besides the ligaments already mentioned, there are likewise two small ones, by which the anterior part of the true fundus of the bladder is connected to the ossa pubis, which shall be described with the neck and sphincter, after the history of the parts of generation in both sexes; and we refer to the same place, all that relates to the connection of the bladder with the other neighbouring parts.

§ 2. *Secretion*

§ 2. *Secretion of Urine.*

THE chyle, which is taken into the blood, contains a good deal of water; the proportion of which would be too great in the vessels, so as to pass into the cellular substance, if it was not expelled again from the body. Therefore a part of this is exhaled through the skin; and another part as large, or often larger than the former, is strained through the kidneys, and is expelled out of the body.

Dr Haller observes, "that the blood of the renal artery being less fluid, as is generally believed, than that of the brain, and probably stored with more water, brought by the serpentine circles of the arteries, deposits great part of its water into those rectilineal tubes of the papillæ; a great portion of which water contains oils and salts, intermixed with earthy particles, or such other matters as are thin enough to pass through with it. But the small diameter of each uriniferous duct itself at its origin, and its firm resistance, seem to exclude the milk or chyle and the coagulable lymph. Hence, therefore, it is, that the blood passes so easily through the open uriniferous tubes, whenever it is urged with an increased celerity; or, by a morbid relaxation, they transmit not only the oily parts of the blood, but even the milk and salts of the meat and drink. But when the strength of the kidney is restored by astringent medicines, the urine returns to its natural state. The nerves likewise have a power of contracting or relaxing these passages; and thus we see that urine, which, in health, is of a yellow colour, becomes watery from sudden grief of mind. A vast quantity is prepared; equal to that of perspiration, and sometimes even more." Later physiologists explain the secretion of urine by observing, that part of the blood by the kidney is changed into this fluid.

The urine, by fire or putrefaction, sometimes by disease,

ease, and in some animals more easily, changes into a volatile alkaline nature, intimately mixed with a fetid oil, partly empyreumatic, yellow, and volatile, and in part very tenacious, to be separated only by the last degrees of fire, under the denomination of phosphorus; a substance shining of itself, and taking fire in the air; and lastly, it abounds more with earth than any other juice of the human body, both of a cretaceous and sparry nature; the latter coming chiefly from the drink, the former also from the solid parts of the body themselves dissolved and mixed with the blood. But there is also a considerable proportion of sea-salt residing in fresh urine; from which it is even separable, after a long putrefaction, in the making of phosphorus; in which process a very great part of the urine is changed into volatile alkali. Nor is the urine wholly destitute of a vitriolic acid, or at least one much a-kin to it; both in that taken from men, as well as cattle. There is, again, a sort of fusible salt separable in the urine, which is cooling, and a-kin to nitre. In fevers, the oily and saline parts of the urine are greatly augmented both in bulk and acrimony.

That the urine is separated in the kidneys, is shown by the very nature of the thing, as it can be drawn out by pressing on its small canals. That it descends by the ureter is shown by the surprising swelling of the kidney, and that part of the ureter which is above the ligature, as well as the emptiness of that part which is below it. In the bladder also, as well as in the kidneys and ureters, there is an immense swelling as often as the bladder cannot receive the urine, or cannot emit it; an obstacle being generated in either place.

Nor does there seem to be any other way for the urine to pass. For although it is certain, that the stomach, like all other membranes, exhales a moisture through its coats; though it is not improbable, from experiments, that the bladder also absorbs; and altho'

the passage of mineral Spaw waters, by urine, be extremely quick ; yet it does not thence follow, that there must be ways, different from that of the ureters, to convey the water from the food to the bladder. For the bladder is, on all sides, separated from the cavity of the abdomen by the peritonæum ; nor is it very likely that the vapours, which either go out from the bladder, or which are derived towards it from other parts, can here find open pores through the peritonæum ; nor do membranes imbibe much that are already wetted, so as to fill their pores with humours. But the urine also which is contained in the bladder distends it even to death ; nor does it find any passage through which it can escape into the pelvis ; and, on the other hand, when the ureters are obstructed with stones, so that the bladder receives nothing from them, it is either quite empty, or contains a very acrimonious and thick urine, manifestly indicating that the water can find no other way from the pelvis into the bladder. And a careful attention to the manner in which mineral waters are discharged by urine, sufficiently demonstrates, that there is no such rapidity therein as is commonly imagined ; but the stimulus of the cold water drank, does, like the external cold applied to the skin, cause a concussion of the bladder and urinary parts, by which they are solicited to repeated discharges of the old urine which was before in the body, and not immediately of that which was last drank. Again, the largeness of the renal vessels demonstrates, that not much less than an eighth part of the blood sent to the body is received at a time, and consequently there are above 1000 ounces of blood conveyed through the kidneys in an hour ; whence it will appear but a moderate allowance, for 20, or even 50, ounces of water to distil from that quantity of blood driven through the kidneys in the same time. Finally, it is certain, that both man and brute animals perish if the ureters are closed up by a ligature ; we then observe also, that no urine can be found in the bladder.

Into the bladder the urine constantly flows, in a continued thread, as we are assured from experience, in morbid and uncommon cases, in which the extremities of the ureters have appeared to the eye. By staying some time in the bladder, and from the absorption of the more watery part, the urine acquires an higher colour, becomes sharper and reddish-coloured. Nor are we fully acquainted with the cause which retains the urine in the bladder. The sphincter is obscure; the depression of the bladder seems to assist, as it descends convex below its mouth upon the intestinum rectum, so that at last the urine arrives at the entrance of the urethra when any quantity of it is collected. Certain it is, that the urine does not flow spontaneously even from a dead carcase.

At length, by its bulk and acrimony irritating the sensible fabric of the bladder, it is thence expelled, first by the motion of the diaphragm and abdominal muscles, by which the intestines are urged against the bladder in a person who is erect, whereby the urine makes itself a way through a narrow and impeded passage; and again, by the peristaltic motion of the bladder itself, arising from the contraction of its muscular fabric.

By the urine, besides the particles of food and water, much matter seems to pass off that is noxious to the human body; especially calcareous earth resorbed from the bones and solid parts, and which would not fail to produce bony crusts and calculi wherever it was stopped; the sparry or gypseous earth of fountains; an acrid oil mixed with salt, so as to assume a volatile nature. The urine, by its retention, disposes to the generation of the stone and gout: when suppressed, it produces sharp fevers; and at last flows back to the brain, and overflows and destroys it.

§ 3. *The parts of Generation in Males.*

Situation in general, and division of these parts. The parts of generation in males are of different kinds, some of them being wholly contained in the abdomen, and others lying without it. From this situation, they might properly enough be divided into external and internal parts; and all those belonging to the first class might be described before those of the second.

But as it is still more proper to have a regard to the œconomy of these parts, according to which, their functions begin in some internal parts, are continued in some external parts, return again to the internal, and are finished in the external; we shall follow the same order in describing them.

The first of these four classes comprehends the spermatic veins and arteries; the second, the testes, epididymis, and scrotum; the third, the vasa deferentia, vesiculæ seminales, and prostates; and the fourth, the corpora cavernosa, urethra, integuments, &c.

Scrotum. The scrotum is the cutaneous covering of the testes. Outwardly, it is a bag common to both, formed by a continuation of the skin of the neighbouring parts, and commonly very uneven, having a great number of rugæ on its outer surface. Interiorly, it is fleshy, and forms a muscular capsula for each testicle, termed *dartos*.

The exterior or cutaneous portion of the scrotum is nearly of the same structure with the skin in general, of which it is a continuation; only it is something finer, and it is likewise plentifully stored with sebaceous glands and bulbs of roots of hairs.

Though it is a common covering for both testicles, it is nevertheless distinguished into two lateral parts by a superficial and uneven prominent line, which appears like a kind of suture, and from thence has been termed *raphe*.

This line is a continuation of that which divides, in the same manner, the cutaneous covering of the penis; and it is continued through the perinæum, which it divides likewise all the way to the anus. It is only superficial, and does not appear on the inside of the skin.

The inner surface of this cutaneous bag is lined by a very thin cellular membrane, through which the bulbs and glands appear very distinctly when we view its inside. The rugæ of the scrotum are in the natural state commonly a mark of health, and then its size is not very large. It increases in size, chiefly according to its length; and then the rugæ disappear more or less, according to the degrees of the preternatural state or indisposition.

The dartos of the scrotum has been looked upon as a true cutaneous muscle; but is chiefly a cellular substance condensed, with a great number of blood-vessels entering into its composition, but without fat. This substance is thin; and by the disposition of its fibres, forms a bag with two cavities, or two small bags joined laterally to each other, and contained within the cutaneous portion.

The lateral parts of these two bags, which are turned from each other, are longer than those which are joined together; and by this union a septum is formed between the testes, which may be called *mediastrinum scroti*.

The raphe or suture already mentioned, adheres to the edge of this septum, and thereby braces down the middle of the cutaneous portion; which from thence appears to have in part two cavities; and this was perhaps what gave occasion to make the French word for the scrotum to be in the plural number. The other edge of the septum adheres to the urethra.

The dartos has a strict connection with the rest of the cellular substance, especially at the upper part below the groin, where its anterior and external lateral portions terminate by a kind of tendinous or ligamentary

tary expansion, which is strongly united to the internal cellular membrane. We have often shown this as a particular fascia lata, which gives insertion to the portions of the dartos just mentioned, and as a broad frænum which keeps the same portions together.

The aponeurotic or ligamentary expansion of the dartos is fixed in the ramos of the os pubis, between the musculus triceps and the origin of the corpus cavernosum of the same side, which shall be described hereafter, all the way to the lower part of the symphysis of these bones. The internal portion of these muscular bags, or that which forms the septum scroti, is fixed to the urethra by means of a communication between the same ligamentary expansion; and another, which shall be explained in its proper place.

Coats of the testes. The particular coverings of the testes are commonly called *coats*; and they are reckoned to be three in number, the tunica musculosa named *cremaster*, vaginalis, and albuginea. The first two are common to each testicle, and to the spermatic rope that belongs to it; and the third is peculiar to the testicle alone.

The tunica vaginalis is the most considerable of the three, and must be described first, in order to conceive the structure and connection of the cremaster, which is very improperly called a *coat*. The albuginea shall be described with the testes.

The tunica vaginalis is a continuation of the vagina of the spermatic rope, which, as it approaches the testicle, is gradually dilated, and forms two capsulæ, one contained within the other, the external being the longest and broadest at bottom; so that there is a void space there left between them, in which the testicle is lodged.

This structure may likewise be explained in the following manner. The vagina having reached as low as the testicle, is divided into two laminæ; the innermost of which is the bottom of the vagina, and the outermost

is expanded round the testicle, and gives it a coat, called *vaginalis*, from the Latin word *vagina*. The ancients termed it likewise *elytroides*, from a Greek word that signifies the same thing.

The inner surface of this coat is lined by a fine membrane, which strengthens the bottom of the vagina, and forms a kind of diaphragm; which prevents all communication between the vagina of the spermatic rope and the tunica vaginalis of the testicle.

Cremaster. The cremaster, improperly termed *a coat*, is a thin muscle or fleshy plane, which runs down round the vagina of the spermatic rope, and terminates in the tunica vaginalis of the testicle.

It surrounds almost the whole vagina; and afterwards expands itself on the upper and external part of the tunica vaginalis, in which it is inserted and lost.

It arises partly from the ligamentum Fallopii, but chiefly from the lower edge of the internal oblique muscle of the abdomen.

It is covered by a very fine cellular membrane, detached from the outside of the aponeurosis of the obliquus externus, round the opening commonly called the *ring*. This membrane is lost in the cellular substance of the inside of the dartos.

From all this we see, that the cremaster is rather a muscle of the tunica vaginalis than a particular coat. Those among the ancients who believed it to be a coat called it *tunica erythroides*, from a Greek word which signifies *red*; but this muscle is not always red, neither is that colour essentially necessary to a fleshy substance.

Testes. The testes are two glandular bodies, situated near each other, without the abdomen, below the interstice between the groins in an adult. The ancients named them *didymi* or *gemini*. Their size is nearly that of a pigeon's egg, and they are of an oval figure, a little flattened at each side. But they are frequently unequal in size in the same person. Fabricius ab
Acqua-

Acquapendente, was consulted frequently by persons who belived they had got a diseased testicle, because it was larger than the other one ; but, upon examination, it was found they had no inconvenience from it, We may consider in each testicle two extremities, two edges, and two sides. One extremity is situated forward and a little upward, the other backward and a little downward ; and their edges lie upward and downward.

At the upper edge they have each an appendix, called *epididimis*, together with which it is involved in several coverings ; and they are both suspended in the common covering, called the *scrotum*.

Each testicle is a spermatic gland formed by a vast number of fine whitish tubes, folded and twisted in different manners, and distributed in different fasciculi, between membranous septa ; the whole being surrounded by a strong common covering, named *tunica albuginea*.

These septa are disposed longitudinally, divaricating from each other on one side, and approaching on the other. They approach each other along one edge of the testicle, and terminate in a long narrow whitish body, as in a kind of axis.

From thence they divaricate in a regular manner, and are fixed by their opposite edges in the inner surface of the tunica albuginea, of which they appear to be a continuation. This white body may be termed the *nucleus* of the testicle, or by some has got the name of *corpus Highmorianum*.

From this description we see, that all these septa are not of an equal breadth ; that the interstices between them are in some measure triangular ; and that the extent of the small tubes, which lie therein, must be very considerable. They have been reckoned to amount to many yards, by taking the sum of all their several portions ; and they may be easily unfolded by a long maceration, which destroys the delicate substance by which

all their folds and convolutions are connected and tied down

The feminal vessels are serpentine, firm, or solid, and exceedingly small; but have been filled with quicksilver, &c. by several anatomists, and first by Dr Monro, Hunter, and Haller. They are collected into bundles above twenty in number, divided by distinct cells or partitions, which descend from the tunica albuginea to conduct the arteries and veins. In each of these cells there is a seminiferous duct to convey the secreted humour from the testicle. The ducts form a net-work, adhering to the surface of the albuginea, and forming inosculations one with another. From the said net, in the upper part of the testicle, ascend ten or twelve ducts; which being contorted together into folds, form as many vascular cones, that are joined together by an intermediate cellular substance; and, lying incumbent one upon another, there form the

Epidydimis, which goes round the outer and posterior margin of the testicle, to which it adheres by its thicker head, joined with a good deal of cellular substance: While in its lower, middle, and more slender part, it adheres in some measure, and is in part free; in such a manner that it intercepts a sort of impervious bag betwixt itself and the testicle. The vascular cones, at the upper part of the epidydimis, by degrees uniting, form at length one duct, which composes the greater part of the testicle (*see* Monro de Testibus), and which grows larger as it descends, being largest at the bottom of the testicle; from whence again ascending along the posterior face of the testicle, in a direction contrary to itself, it by degrees spreads open its spiral convolutions, and comes out much larger, under the name of *vas deferens*.

The epidydimus thus formed, may be reckoned a production of the testicle, or a kind of testis accessorius; and it resembles in some measure an arch supported by its centre or frame. It is more contracted at

at the middle than at the extremities, by which it is closely united to those of the testicle.

Between its extremities it does not immediately touch the testicle; but is only loosely connected to it by the duplicature of a very fine and almost transparent membrane, as by a kind of ligament. This membrane is the continuation and duplicature of the tunica albuginea, or proper coat of the testicle; which having supplied the place of a ligament to the epididymis, afterwards invests it.

The epididymis is flat, a little concave on the under side or that next the testicle, irregularly convex on the upper side or that turned from the testicle: and these two sides are distinguished by two angular edges; by the innermost of which it is connected to the testicle in the manner already said, but the outer edge and flat side are loose and free.

The anterior extremity or head of the epididymis arises from the testicle; and the posterior extremity or tail, which likewise adheres very closely to it, is incurvated from behind, forward and a little upward, and contracting by degrees forms the *vas deferens*. Besides the ducts commonly described in the epididymis, late anatomists have sometimes found a duct wandering off from the epididymis; but its termination was not well understood. It was supposed to terminate in the lymphatic system; but in a few subjects Dr Monro has found such a duct arising from one end of the epididymis and running into the other end.

By this description of the extremities and edges of the epididymis, Winslow demonstrated, many years ago, a method to discover whether a testicle, viewed extra situm, belongs to the right or left side.

The spermatic vessels. The spermatic arteries go out most commonly from the anterior part of the inferior aorta, near each other, and about an inch lower than the arteriæ renales. Their origin oftentimes varies: for I have observed them to arise from the renal artery;
and

and sometimes they go out higher, lower, or more laterally than is common, and each artery has been seen to arise from different places. Sometimes there are two on each side, one arising a little below the other; or at other times one comes from the aorta, the other from the renal artery on the same side; and here they give off branches to the cremaster muscle, &c.

They run down obliquely in the posterior part of the abdomen within the cellular substance of the peritonæum, passing insensibly from behind forward; and so parting gradually more and more from the aorta, they cross over the foreside of the ureters, and run through the openings or rings of the abdominal muscles along with the elongations or productions of the cellular portion of the peritonæum.

They are small at their origin; and, in their course downward, they give off pretty considerable lateral ramifications, to the membrana adiposa, peritonæum, and also to the mesentery, where they seem to communicate with the mesenteric arteries. After producing numerous branches to these parts their size is not diminished: sometimes, on the contrary, it is much increased, owing seemingly to the arteries, which are very long, and their coats thin, not being sufficiently able to resist the pressure of the blood.

They sometimes pass through the areolæ or meshes of the spermatic veins; and before they go out of the abdomen, they are divided into very fine rami, which run in a more or less winding course, almost parallel to each other.

Afterwards they enter the cellular productions of the peritonæum, which serve them for vaginæ. They do not fluctuate indifferently from one side to the other of these vaginæ; but are connected along their inner surface by thin membranous laminæ, which are likewise continuations of the cellular substance of the peritonæum.

The arteries continue the same winding course within
in

in these vaginae, passing before the vasa deferentia, which are likewise contained in them; and at length they terminate by ramifications in the epididymis and testes, in the manner that shall be afterwards explained.

The spermatic veins accompany the arteries, and have nearly the same course. The right vein ends commonly in the trunk of the vena cava, and sometimes it ends in the union of the right renal vein with the vena cava, and sometimes three veins on the right side end separately in the trunk of the vena cava. The left spermatic vein ends most commonly in the vena renalis sinistra.

After getting into the abdomen they receive a branch which communicates with the vena mesenterica, and consequently with the vena porta. A little higher, but below the place where they cross over the ureters, they receive a considerable branch, one of which communicates with the vena capsularis, the other frequently with the vena renalis; and in their whole course thro' the abdomen, they receive branches from the peritonæum, mesentery, &c.

They differ from the spermatic arteries, not only in that they are larger, and their coats thinner, but also in being more divided and multiplied in the abdominal muscles; and as they are formed of a larger fasciculus of ramifications, the ancients gave to them, and to the arteries, the name of *vasa pyramidalia*.

These ramifications often communicate with each other in this course, and form a great number of areolæ, contortions, and convolutions, so as to represent a kind of plexus, which is connected to the cellular vagina of each side by very fine laminæ; and the artery which accompanies the vein crosses it in several places, and runs through the areolæ in different directions. These frequent convolutions gave rise to the name of *vasa pampiniformia*, formerly given to these vessels; and their particular adhesions to each other at some places,

places, made it believed that there were real anastomoses between the artery and the vein.

Leal Lealis, an Italian anatomist, not attending to the lateral ramifications of the spermatic arteries and veins, believed himself able to establish and demonstrate these pretended anastomoses. The experiments made by him on living animals prove nothing. His way was, to make a common ligature on both vessels a little above the testicle, and another on the trunk of the vein, after he had emptied it. Then pressing the aorta to force the blood into the spermatic artery, the vein which he had before emptied was found to be presently filled.

From thence he concluded, that the course of the blood to and from the testicle being obstructed by the inferior ligature, there must be some anastomoses between the two ligatures, through which the vein was supplied with blood. But it is very plain, that this effect was owing to the lateral ramifications of the spermatic artery and vein, and not to his pretended anastomoses. These fine lateral ramifications were well known to Eustachius, but had escaped Leal Lealis.

Vasa deferentia. The vasa deferentia are two white solid flattened tubes; one lying on the right side, the other on the left. From the epididymis, of which they are continuations, as has been already said, each of them runs up in the cellular vagina of the spermatic vessels, as high as the openings in the abdominal muscles; the blood-vessels lying forward, and the vas deferens behind them.

This fasciculus thus formed, by the blood-vessels, vas deferens, and their common covering, is termed the *spermatic rope*. The covering is smoother on the outer than on the inner side; and for that reason it has been looked upon as a vagina; the internal substance of which is most cellular, and connects all the vessels together, while the external forms a covering to invest them.

The

The vas deferens having reached the membranous lamina of the peritonæum, where that lamina runs over the orifice of the vagina, separates from the blood-vessels, and runs backward, in form of an arch, in the cellular substance of the peritonæum, as far as the nearest side of the bladder.

It passes afterwards behind the body of the bladder, to which it adheres very closely, as also to the lamina of the peritonæum which covers it, and then continues its arched course towards the neck of the bladder, where both vasa deferentia meet, and their arches terminate.

In this course, the vas deferens passes behind and crosses the neighbouring umbilical artery; crosses the extremity of the ureter of the same side, in its passage between that extremity and the bladder; and having got behind the bladder, it meets the vas deferens of the other side between the insertions of the ureters, and they run down together to the neck of the bladder.

This canal, which at the origin of the epididymis is pretty large and plaited, becomes immediately afterward smaller and smoother, and continues in that form till it gets behind the bladder, where it begins again to be larger and more uneven.

It arises from the angular portion or posterior extremity of the epididymis; and from thence runs forwards in a very oblique course, on the posterior half of the epididymis, where it is a little incurvated as it joins the back-side of the spermatic vessels.

The texture of the smooth portion of this canal is very solid, and in a manner cartilaginous, especially near the surface of its cavity; which, though very narrow, is still kept open by means of the solidity and thickness of its sides.

The cavity of the vas deferens is cylindrical, though the whole tube is flat, and its external circumference oval, as may be seen by cutting it transversely; and the cavity enlarges as it passes behind the bladder. The
termi-

termination of these canals must be referred to the history of the urethra.

Vesiculæ seminales. The vesiculæ seminales are soft whitish knotted bodies, about three or four fingers breadth in length, one in breadth, and about three times as broad as thick, situated obliquely between the rectum and lower part of the bladder, in such a manner, as that their superior extremities are at a distance from each other, and their lower extremities are contiguous.

They are irregularly round on the upper part, and their breadth decreases gradually from thence. By the union of their lower extremities they form a kind of fork, the branches of which are broad, and bent like rams horns. These extremities are very narrow, and form a small neck, which runs behind the bladder toward its orifice, and continues its course in the groove of the prostates, through the substance of the contiguous portion of the urethra, till its extremities pierce the caruncula in the manner already said.

The inner substance of the vesiculæ is plaited, and in a manner distinguished into several capsulæ by contorted folds. Their external surface is covered by a fine membrane, which serves for a border and frænum to the folds, and is a true continuation of the cellular substance of the peritonæum. The vesiculæ may easily be unfolded, and all their contortions straightened; and by this means they become much longer than in their natural state.

Their inner surface is villous and glandular, and something similar to the inner surface of the gall-bladder, or like the cells of a honeycomb. This furnishes a particular fluid, which exalts, refines, and perfects the semen, which they receive from the vasa deferentia, and of which they are the reservatories for a certain time.

The passage of the vasa deferentia into the vesiculæ is very particular. We have already observed, that these
canals

canals are incurvated behind the bladder, and that their contracted extremities unite at that place. They unite in an angle, and run between the contiguous extremities of the vesiculæ; and this union is so close, that the adhering portion seem to form only one middle septum, between two small tubes; each of which is formed, partly by the extremity of one vas deferens, and partly by that of the neighbouring vesicula.

This lateral union of the extremities of the vas deferens, and vesicula seminalis on each side, forms likewise a kind of short septum, which terminates in a crescent, like a small semilunar valve; and the extremity of the vas deferens is narrower than that of the vesicula. By this mechanism, the fluid contained in each vas deferens has liberty to enter the contiguous vesicula; but that contained in the vesicula cannot return into the other canal.

If we blow into one of the vasa deferentia, after having compressed the urethra, the air inflates the contiguous vesicula seminalis, and the bladder of urine, without passing into the vesicula or canal of the other side, except we blow with too great violence.

Afterwards the two small tubes, formed each by the extremities of the vas deferens and vesicula, run in between the basis of the prostates and canal of the urethra; and perforating the sides of that canal obliquely, they terminate in the caruncula in the manner already said. That of the right has no communication with that of the left.

The vesiculæ feminales receive their blood-vessels from those which supply the rectum and bladder. They have lymphatic vessels which carry off the thinnest part of the semen into the circulating system.

Prostatae. The first portion of the urethra, or that which is not covered by the cavernous substance, and which from the bladder to the bulb is only a membranous canal, is sustained by a large solid whitish mass, of the figure of a chefnut, and situated between the bladder

der and the bulb of the urethra ; its basis being toward the bladder, the apex or point toward the urethra, and the sides lying upward and downward.

This body is termed the *prostates*, from a Greek word that expresses its situation before the vesiculæ seminales, and implies a plurality, because it appears to be divided into two lateral lobes by a hollow groove, which runs through its upper side from the basis to the apex. The first portion of the urethra lies in this groove, adhering very closely to the prostates which surround it for about half an inch in length ; but there is only a very small part of the prostate upon the fore-side of this passage.

The body of the prostates lies on the intestinum rectum, and the apex is under the internal labium of the cartilaginous arch of the ossa pubis. The inner substance is spongy, but very compact ; and in each lobe there are several folliculi, which open into the first portion of the urethra, toward the bottom of the groove, as we shall see hereafter. The small portion of the urethra, between the apex of the prostates and the bulb, perforates a ligamentary substance, which is situated at the under and back part of the symphysis pubis. This portion is very short, its length being no more than what is sufficient to pass through the hole in the ligament ; the backside of which consequently touches the apex of the prostates, and its fore-side the bulb of the urethra. This portion might be called the *neck* of the urethra, and that which lies between the body of the bladder and the prostates might be called the *neck* of the bladder.

Glans. The spongy substance of the urethra having reached the extremity of the corpora cavernosa, forms a large head called the *glans*, which crowns the three spongy pillars ; with this difference, however, that it is a continuation of the spongy substance of the urethra, and only adheres to the extremity of the corpora cavernosa, without any direct communication.

It is for this reason, that if we blow into the spongy substance of the urethra, the glans is presently inflated, and no air passes into the corpora cavernosa: but when we blow into one of these bodies, the air passes immediately into the other, the urethra and glans remaining as they were.

The figure of the glans is that of a rounded cone, a little flattened at the lower part, and with an oblique prominent basis; the circumference of which is something greater than that of the corpora cavernosa.

The spongy substance of the glans is thick and uniform next the corpora cavernosa; but next the urethra it is perforated by a continuation of that canal, and is there no thicker than the urethra before the formation of the glans.

Therefore the canal of the urethra does not lie in the middle of the glans; but continues its direct course through the lower flat side of it, all the way to the extremity, where it terminates by an oblong orifice.

All the convex surface of the glans is covered by a fine villous substance, and that again by a fine membrane, resembling the red part of the lips. The circumference of the basis of the glans has a double row of small papillæ, which may be reckoned sebaceous glands, from which a thick matter is discharged.

Caruncula. We have several things to take notice of in the cavity of the urethra. At the bottom of the cavity of the first portion, or that which lies within the prostates, there is a small oblong oval eminence, pretty large on the back part, and terminating forward in a point, called *caruncula*, or *verumontanum*. The large portion of it is commonly perforated by two holes, sometimes only by one, and very seldom by three; and these are the excretory orifices of the *vesiculæ seminales*; of which hereafter. Each orifice has a small thin membranous border, which may serve for valves to the excretory ducts of the *vesiculæ*.

On each side of the large portion of the *caruncula*,
VOL. II. F f there

there are five or six holes ranked in form of a crescent round its lateral parts, which are the orifices of the excretory ducts of the prostates that come from the folliculi already mentioned, and run in an oblique course to the orifices, in a kind of membranous duplicature.

Corpora cavernosa. The corpora cavernosa are two ligamentary and very limber tubes, united laterally to each other through the greatest part of their length, and solid at their two extremities; two of which are connected together, and rounded like the end of a finger; the other two divaricate, like the branches of the Greek τ ; and, diminishing gradually in size after the divarication, terminate in an oblique point. These divaricated and pointed extremities may be called the *roots*, and the round extremities the *heads*.

These two bodies are almost cylindrical, being round, and of an equal diameter from the roots to the heads, where they are in some measure conical. The ligamentary substance of their sides is elastic, and composed of fine close fibres; which are partly transverse, and partly more or less oblique.

The cavity of these ligamentary tubes is entirely filled by a strong cellular or cavernous substance, which does not seem to be a continuation of the substance of the sides. These cells communicate with each other, and are always more or less full of blood, resembling pretty much the cellular substance of the spleen, only with this difference, that the sides of the cells are thicker in these cavernous bodies, and without any additional substance.

By the union of the two corpora cavernosa, two external grooves are formed; one on the upper side, the other on the lower. The lower groove is something broader than the upper; and it is filled through its whole length by a third tube, narrower than the corpora cavernosa, called the *urethra*; which shall be presently described.

The roots of the corpora cavernosa are fixed, each,
to

to the edge of the small ramus of the ischium and os pubis. They meet at the symphysis of the ossa pubis, where each of them becomes a cylindrical tube, and unites with the other in the manner already said.

The heads or rounded extremities join the basis of a distinct body, called the *glans*, which is an expansion of the urethra, and closely united to it in the manner that shall be explained hereafter.

By the union of the corpora cavernosa from their roots to their round extremities or heads, a particular septum is formed by the transverse fibres of both. Between the fibres of this septum several small void spaces are left, by which the corpora cavernosa communicate with each other; and therefore, by blowing into one of them, we presently inflate the other. Toward the rounded extremities the septum diminishes every way.

Urethra. The urethra is the third spongy tube which composes the penis; and it adheres to the corpora cavernosa, through the whole length of the inferior groove formed by their union. It differs from the other two, both as it is narrower, and as it forms a true hollow canal. Its substance is spongy or cavernous, except a small portion next the bladder; and its inner and outer surfaces are membranous. It extends from the neck of the bladder to the extremity of the penis.

It is at first no more than a membranous canal continued from the anterior opening of the bladder, at the place called the *neck* of the bladder, which is a name that would be more proper for this portion of the urethra. It descends from its origin to the under end of the symphysis pubis; then it ascends before the symphysis to the root of the penis; and at last redescends to the point of the glans.

About a finger's breadth from this part, it joins a cavernous substance like that of the two other tubes, only smaller, which surrounds it through the whole extent of the inferior groove of the corpora cavernosa.

But before this spongy substance begins to surround

the urethra, it forms a distinct oblong body, like a pear, which is connected only to the lower convex side of the canal; and afterwards being split on each side, invests it quite round. This body is called the *bulb* of the urethra, being larger than any other part of that canal, and divided interiorly by a very fine membranous septum into two lateral parts; and therefore, when it is inflated, it appears to be double, or with two heads.

Lacunæ of the urethra. The inside of the canal of the urethra is lined by a fine membrane, full of capillary blood-vessels; and its surface is perforated by a great number of oblong holes, or small lacunæ of different sizes, the largest lying near the glans.

These lacunæ or orifices of the excretory ducts of the same number of small glands, are dispersed through the substance of the urethra: which ducts run for some way in the spongy substance along the convex side of the internal membrane of the urethra, and open obliquely from behind forward into the great canal. The edges of the lacunæ are semilunar, or like a crescent, because of the obliquity of their opening.

Anti-prostata. A little way before the verumontanum, without the urethra, we meet with two lacunæ more considerable than the rest, and their ducts are very long. These lacunæ and ducts lead to two glandular bodies, situated, one on each side, between the posterior and lateral parts of the muscoli acceleratores urinæ, and the bulb of the urethra. Each of them is about the size of a garden pea; but they are oblong and flat, and covered entirely by the accelerator muscles. They are known by the name of *prostatæ inferiores*; but if their situation be carefully examined, they will be found to be higher than the true prostatæ. They are likewise termed *glandulæ mucosæ* of Cowper, who has given a description of them (See Phil. Trans. 1699); but they were first described by Mery in 1684. They seem

seem to be a-wanting in some subjects; for certain anatomists of accuracy have searched for them without finding them. A third gland of this kind is described by Cowper as being seated a little more anteriorly; but this also, Heister observes, is wanting in bodies dissected by our best anatomists.

Orifice of the urethra. The cavity of the urethra resembles nearly that of a small writing-pen. It is not every where round, and towards the glans becomes broader and flatter on each side, especially in the glans itself, where there is a kind of oval or navicular fossula.

This canal terminates at the extremity of the glans by a narrow oblong orifice or fissure, which is much less than the rest of the cavity. The commissures of this small fissure are turned, one toward the convex, the other toward the flat side of the glans; and the labia of the fissure are its lateral parts; and it seems to be surrounded by fleshy fibres.

The common integuments. The integuments which cover all these parts are three or four in number. The first is the skin with the cuticula; the second is the common cellular membrane, which in this place seldom contains any fat; the third is termed *nervous*; and the fourth is a particular cellular membrane, which is not always to be found.

Præputium. The first of these integuments, the skin, is a continuation of that of the pubes and scrotum; and it adheres to the second all the way to the basis of the gland, where that second integument ends. The rest of the cutaneous integument covers the glans without adhesion, and terminates by an opening. This portion is named *præputium*; and along the whole lower or back side, both of the whole integument in general, and of the *præputium* in particular, there runs a fine suture, which is a continuation of the raphe of the perinæum and scrotum.

The inner surface of the præputium is lined with a fine membrane from the opening all the way behind the basis of the glans, and the same membrane is folded from behind, forward, round the glans, forming the proper integument thereof, and covering very closely its whole villous surface, as far as the orifice of the urethra, where it joins the membrane which lines the inside of that canal.

This proper membrane of the glands, and internal membrane of the præputium, form conjointly along the flat part of the glans, from its basis to the orifice of the urethra, a membranous duplicature, which like a septum or mediastinum divides this part into two lateral portions, and limits the motions of the præputium; for which reason it is called *frænum præputii*.

The surface of the internal membrane of the præputium discharges a fluid which prevents it from adhering to the glans, and perhaps serves likewise to dilute that which is collected at the basis of the glans, from the glandulæ sebaceæ, already mentioned.

The second common integument of these parts, is nearly the same with what is every where found under the skin, except that it is not filled with fat, and that it is more fibrous than cellular, and a little loose. It accompanies the skin to the basis of the glans, as has been already observed.

Ligamentum suspensorium. The third common integument, improperly called *tunica nervosa*, is of a firm, elastic, ligamentary substance, and its fibres are sometimes of a yellowish colour. It invests the corpora cavernosa and urethra from the glans to the symphysis of the ossa pubis; and at some distance from these bones, it forms on the superior groove of the corpora cavernosa a close duplicature; and by this duplicature, a flat broad ligament which runs directly upward, and is inserted in the forementioned symphysis, as far as the
tendinous

tendinous basis of the musculi pyramidales of the abdomen.

This ligament has been called *ligamentum elasticum*, because it yields and recovers itself; and *suspensorium*, because it suspends these parts, by means of its insertion in the symphysis. It sends off a detachment or ala toward each side, one edge of which is fixed between the musculus triceps and the corpus cavernosum, and forms the ligamentary expansion in which the dartos is inserted, as has been already said. It seems likewise to send down another elongation directly to the perinæum and anus.

The fourth integument of these parts is the tunica cellulosa of M. Ruysch, which immediately surrounds the corpora cavernosa and urethra, lying between these and the third integument, from which it seems to be distinguished only by the closeness and fineness of its texture; and it is sometimes hardly perceivable.

The muscles. Several muscles are inserted in the parts which we have just described. They may be reckoned to be six in number, two for the corpora cavernosa, two for the urethra, and two common muscles called *transversales*. (See Vol. I.)

Blood vessels. The arteries of these parts come chiefly from the iliacæ internæ or hypogastricæ, and the rest from the iliacæ externæ or crurales. The principal arteries are termed *pudicæ*, of which one is external, the other internal.

The pudica externa sends a branch to each side, which having passed out of the pelvis by the side of the os sacrum, runs on the inside of the tuberculum ischii, to the roots of the corpora cavernosa, along the inside of the musculi ischio cavernosi or erectores. It sends ramifications to the bulbous head of the urethra and to the corpora cavernosa; and together with the glutææ, with which it communicates in its passage, it likewise supplies the scrotum.

The pudica interna having furnished the intestinum

rectum, bladder, vesiculæ seminales, and prostates, communicates with the hæmorrhoidales, passes under the arch of the ossa pubis, and partly enters the corpora cavernosa, and partly runs along their upper side, sending off small lateral branches, which surround these bodies, like irregular half arches, and penetrate them by numerous ramifications.

The crural arteries send each likewise a branch, which, running behind the contiguous crural vein, is distributed to the integuments of the penis, by the name of *pudica externa*, and communicates, by lateral ramifications, with those of the *pudica interna*. These communications are not only between the internal and external pudicæ of the same side, but also between those of both sides, which reciprocally communicate with each other.

The distribution of the veins follows nearly that of the arteries; but they have more ramifications and communications, as in other places. The principal vein is that which runs along the whole superior groove formed by the union of the corpora cavernosa. It passes directly under the symphysis of the ossa pubis, between the two arteries. It is very large, often double, and very seldom triple, but the trunks do not separate while in the groove; and it has a great number of valves.

This great middle vein opens into the branches of both hypogastric veins. The lymphatic vessels of the penis appear to go chiefly into the plexus in the groin, on the two inner sides of the pelvis, about the middle of the arch of the ossa pubis. At this place we observe a venal plexus, which covers the upper convex side of the first portion of the urethra, before it is surrounded by the spongy substance.

The spermatic vessels, of which we have already described the origin and course all the way to where they go out of the abdomen, having reached on each side near the testicle, are divided into two principal fasciculi, one
of

of which is larger than the other. The largest is the anterior, and is distributed through the testicle, by a prodigious number of very fine capillary ramifications, which accompany all the convolutions and folds of the small canals.

The other fasciculus is posterior, and is distributed to the epididymis in the same manner.

The spermatic artery is accompanied by a ramus of the epigastric artery, which runs down on the side of it as far as the testicle, where they communicate reciprocally with each other. There is sometimes a small ramus of the hypogastric artery, which accompanies the vas deferens to the epididymis, and there communicates with the arteria spermatica. The testicle has likewise numerous lymphatic vessels, which run in the spermatic cord, and join the lymphatics of the pelvis and loins.

Nerves. The nerves of these organs come from the lumbares and sacri; and they communicate with the sympathicus maximus, and plexus mesenterici. Near the arch of the os pubis, they form together, on each side, a particular rope, which passes under that arch along the upper side of the neighbouring corpus cavernosum, near the artery already mentioned.

In their passage over the corpora cavernosa, they send off a great many rami, which surround these bodies on all sides, between the skin and ligamentary integument; being so disposed, as that the arteries lie between them and the middle vein. They must be examined presently after the skin has been raised, because when the ramifications are dried by the air, they disappear.

The nerves of the testicle are very small. They are formed by the renal and mesenteric plexus. The nerves of the loins send small branches likewise along with these. They run along the spermatic cord; but it is exceedingly difficult to trace them into the testicle.

There is likewise one nerve on each side; which being

ing produced from the union of the second, third, and fourth pairs of the nervi sacri, especially from the third, goes out of the abdomen above the ligamentum ischio-sacrum, passes by the inside of the tuberosity and small branch of the os ischium, and is distributed to the corpora cavernosa, to the muscles belonging to them, and to the neighbouring parts.

§ 4. *Secretion of the Semen.*

THE vessels belonging to the genitals constantly arise near the kidneys, and almost in all kinds of animals; by which nature seems to have intended a double usefulness in one organ, which might be able to discharge the urine and semen, and to bear a relation likewise to the genital parts, though placed at a considerable distance, in a space betwixt the tops of the thighs, and subservient to cleanliness, modesty, easiness of birth, and the force of straining in delivery.

The semen masculinum is first formed in the testicle; then repositied in the seminal vesicles; afterwards ejected from the penis into the uterus, where it renders the female ovum prolific: and therefore this must be the order of our inquiry into these particulars.

The testicle is defended by various integuments, and is composed of various kinds of vessels and of nerves.

The blood, moved slowly and in a small quantity through the spermatic artery, by which it is brought to the inner fabric of the testicle, is there drained into very small vessels, which carry their fluids to the *seminal vessels*, although we are ignorant of the manner by which the arteries communicate with these canals, the bundles of which form the whole substance of the testicle. These seminiferous vessels are exceeding small, serpentine, firm, or solid, and have a very small light in proportion to their membranes. They are collected together into bundles, about twenty in number, divided by

by distinct cells or partitions, which descend from the albuginea to conduct the arteries and veins. In each of these cells there is a feminiferous duct, to convey the secreted humour from the feminiferous vascules. Twenty or more of these ducts form a *net-work*, adhering to the surface of the albuginea, and forming inosculations one with another; and quicksilver is very easily poured from them into the surrounding cellular texture. From that net in the upper part of the epidydimis, ascend twenty or thirty ducts, which, being contorted into folds, form as many *vascular cones*, that are joined together by an intermediate cellular substance; and lying incumbent one upon another, then form the head of the epidydimis, and in that head soon meet together into one duct without the testicle.

This duct being intricately wove by an infinite number of folds and serpentine flexures, after a manner not imitated in any other part of the body, and connected together by a great number of loose cellular strata, is afterwards collected by a membrane of the albuginea into one bundle, called the *epidydimis*. But the duct of which it is composed grows larger as it descends, being largest at the bottom of the testicle; from whence again ascending along the posterior face of the testicle, in a direction contrary to itself, it by degrees spreads its spiral convolutions, and comes out much larger, under the denomination of *ductus deferens*.

This is the course described by the semen, propelled forward by the motion of the succeeding juices in the testicle; and perhaps, in some measure, though slowly, by the contraction of the cremaster: as we may reasonably suppose, from the numberless spires and convolutions formed by the epidydimis, obstructing almost every kind of injection; and, as we may conclude, from the length of time that is required to fill the seminal vesicles again, after they have been once exhausted.

The

The cylindric ductus deferens being made of a very thick spongy substance, included betwixt two firm membranes, bored through with a very small tube, ascends in company with the cord of the spermatic vessels, and together with them passes through the ring of the abdomen: thence it descends into the pelvis; and applying itself to the bladder betwixt the ureters, it soon after meets the subjacent receptacles, called the right and left *vesiculæ seminales*. Here it goes along the inner side of the vesicle, as far as the prostate glandule; and dilating in its passage, forms a serpentine flexure, that begins itself to put on a cellular appearance. But very near the prostate, being continued from these cellular bendings, with a conical duct coming out from the vesicle, it unites in a very acute angle, which does at the same time itself form a conical duct; which being continued rather with the vas deferens, and sinking through the prostate gland, is there wrinkled into a large fold, and going off outward at right angles from its companion on the other side, and afterwards straitened, it opens into the urethra, through a little hollow protuberance, which has a long tail or descent, and is laterally perforated with two very small openings, one on each side. By injecting a liquor into the ductus deferens of a dead subject, we perceive that it flows both into the urethra and into the seminal vesicle, but more readily into the former; but in a living person the semen never flows out but in the act of venery; and consequently the ductus deferens conveys all its semen, without further delay, over a retrograde angle, to the *seminal vesicles*.

The liquor deposited into this reservoir, is in the testicle yellowish, thin, and watery: and the same nature it retains in the vesicle, only becomes there somewhat thicker and higher coloured; and lastly, it is white in mankind, when it has mixed with the liquor of the prostate. It has a sort of heavy or strong smell, of a peculiar

peculiar kind in each class of animals; and it is the heaviest humour in the human body. In water, however, a part goes off into a kind of cuticle, like a cobweb, that swims in the liquid; the greater part, which is seemingly of a pulpy nature, falls to the bottom. In the semen which is long kept by chaste people, shining globules mixed with the white liquor are easily to be seen. It has a very great quantity of mucus.

Without the conveyance of this into the womb, according to the opinion of Haller, no class of animals, of which there are two sexes, can be fecundated so as to propagate their species; but Spallanzani has clearly proved, that in certain kinds of the animals commonly called *oviparous* (excepting birds), fecundation takes place without the body of the female. The microscope shows, that in man, as well as in all other male animals, the seminal liquor is full of living animalcules, resembling eels, only with a thicker head; and that these are always present in healthy semen, from the time that a person comes of age; but, before that time, and in those who are sterile from a gonorrhæa, they are absent. That they are animalcules, appears evidently from their various motions, restings, and gestures of body.

It has been much doubted what could be the use of these animalcules; and in another place we shall consider the dispute concerning the opinion that they are as it were the first appearance of the future animal. Haller considers the nature of the seminal animalcules as the same with that of the eels in vinegar or paste.

That the semen is produced from the lymph of the blood, and that the chyle is added to the lymph, will appear probable from the sudden alacrity to venery that happens after eating, and which is lessened by fasting. It is compounded of the liquor of the testicles and seminal vessels, the former indeed being more evident in some animals, and the coagulable milk of the prostate

prostate gland. That liquor, however, only fecundates which is generated in the testicles; as we see from geldings, which, though they have the seminal vessels and prostate, are yet barren.

The seminal fluid is retained in the vesicles as long as a man neither exercises venery, nor sports in imaginary dreams. But it is always a stimulus to the animal appetite of venery, as long as it is there present in any quantity. But besides this, there is a considerable strong, volatile, and odorous part of the semen absorbed again into the blood, where it produces wonderful changes as soon as it begins to be formed; such as the protrusion of the beard, the covering of the pubes, a change of the voice and passions, horns in cattle, &c. for these changes in the animal are not the consequences of age, but of the seminal fluid, and are always absent in eunuchs. The growth and strength of castrated animals are constantly diminished; and in like manner the fierceness of their temper, and the strong smell of their whole body, are remarkably weakened. And from the examples of some animals, and even of mankind, it appears, that the irritation of this fluid has occasioned death, by exciting convulsions. A retention of the semen may follow from a narrowness of the excretory duct, a scirrhus of the prostate, and other causes not sufficiently known.

The quantity of semen expelled at one time from the human vesicles is but small, more especially in a man who has not long abstained from venery; and it is natural to think that the liquor can be but slowly produced from so small a subcutaneous artery. Its generation is accelerated by love, by the presence of the beloved woman; so that it distends its vessels with a sense of pain. Nature herself, therefore, enjoins venery, both for preserving the human race, and likewise the health of every sound man. That it comes from the testicle, is shown by diseases; in which the ductus deferens being obstructed, a swelling of the testicle has ensued.

ensued. The vesicles never are emulged, except by venereal actions and appetites.

Seeing the semen is in small quantity, that it might be projected with a greater force, and to a farther distance, nature has joined another humour, which is generated by the *prostate*; which prepares a thick, white, soft, or cream-like liquor in a large quantity, which is poured out at the same time and from the same causes with the semen itself, into a little valley or channel at each side of the openings of the seminal vesicles, where, mixing with the seminal fluid, it imparts the white colour and viscosity which the semen possesses.

But it was necessary for this canal of the urethra to be firm and capable of a direct figure, that it might be able to throw the semen with some strength into the distant womb; and therefore a threefold cavernous body surrounds it.

Into the cavernous body of the urethra, the blood is poured out from the arteries, which come from deep branches sent off from the external hæmorrhoidals; the truth of which is demonstrated by the injection of any kind of fluid, which, being urged into the said arteries, easily flows into these cellular spaces surrounding the urethra. But these are not naturally turgid with blood, because there are veins open and numerous enough in proportion to receive and return what is poured in by the arteries; but if the return is impeded by compressing those veins from the powers hereafter mentioned, the blood is then retained within the cellular spaces, while the arteries continue to import it more swiftly and strongly than the veins return it. Thus the stagnant blood distends the bulb of the urethra, together with its cavernous body, and the glans itself. But this is performed generally at the same time, when the other cavernous bodies of the penis, with which this of the urethra has no communication, are likewise rigidly distended.

These cavernous bodies of the penis, having their spongy fabric distended in coition by the blood retained by the veins, and still propelled by the arteries, become rigidly turgid, and sustain the otherwise flaccid or but weakly filled urethra, in such a manner that it may be able to conduct the semen into the distant womb. All this is demonstrated from the dissection of brute animals in the act of venery, from an artificial erection, and from the injection of liquid matters into the vessels of the penis. The cause is love, the desire of pleasure, the friction of the glans, various irritations of the bladder, testicles, feminal vessels, urethra, from the urine, from abundance of good seed, from the venereal poison, from cantharides, whipping with rods, or convulsion of the nerves. But the cause of this distention remains still to be explained.

In order to distend the penis, there must be either a compressure of the vein, bringing back the blood from the cavernous bodies of the penis or urethra; or at least it is necessary that there be a constriction of the lesser veins that every where open within the cavernous bodies, to hinder them from absorbing and returning the blood from the arteries. The first, however, may be effected by the levator, drawing up the prostate and bladder: but it is very probable, that, as we see in the nipples of the suckling mother, in the gills of the peacock, and in the blushing or redness of the face from passions of the mind, as well as from brute animals, which all couple without the use of any erector muscle; from the erections which take place in animals totally different from man, and especially those which take place in birds very quickly; from the rest of the erector muscles themselves in the libidinous erection of the penis, and from their unsuitness for compressing the veins; from all these, we say, it is probable, that the course of the blood through the vein may be retarded without the immediate use of any muscle; and that by the power of the numerous, small, latent, nervous
bridles,

bridles, by whose constriction, from the force of pleasure, the veins are compressed and straitened, so as to return less blood to the trunks, at that time, than what is imported by the arteries, which are not only free from any stricture, but, by the increase of pulsation, bring a greater quantity of blood, which cause also contributes to produce the erection. But the cause of this constriction in the nervous bridles or spincters themselves depends upon a mechanical irritation of the nerves, and from something more subtle, by which means the penis is immediately erected.

A long continued and violent erection is at last joined commonly with an expulsion of the semen; and this requires much greater force than is requisite for the erection only. For the semen follows at that time when the irritation of the nerves is arrived at its greatest height: and in natural venery indeed, when at length the cellular spaces of the urethra and its continuous glans, which are at last filled, become so far distended with a large quantity of warm blood, that the nervous papillæ, stretched out in the latter, become violently affected from the irritating or pleasing cause; the seminal vesicles are emptied by the levator muscles of the anus, which press them against the resisting bladder with a convulsive motion, excited either by a voluptuous imagination, or from the pruritus that is exquisite in the nerves of the glans, principally in its lower part, which is in the neighbourhood of the frenum. Hence the semen is never discharged with any of the urine, in an healthy man; because the expulsion of it requires the bladder to be closed or drawn up firmly together; for, while lax, it affords little or no resistance to the seminal vesicles. The transverse muscles seem to dilate the canal of the urethra for the reception of the semen expressed from the vesicles.

Soon afterwards the powers constringing the urethra are, from the irritation of the very sensible fabric of that canal, put into action. To this constriction con-

duces principally the accelerator, which makes a powerful concussion of the bulb and adjacent part of the urethra, so as to propel the contents more swiftly, in proportion as the bulb has a larger diameter than that of the urethra. But that this may act firmly, the sphincter of the anus, together with that of the bladder, must be well shut. The accelerator muscle seems also principally concerned in the erection, by compressing the veins of the corpus cavernosum of the urethra. At the same time the *erectores penis*, as they are called, arising from the tubercles of the ischium, become strong, and are inserted into the cavernous bodies, sustaining the penis as a sort of medium betwixt the transverse and perpendicular direction. Thus the semen is drove into the vagina, and into the uterus itself, in a prolific coition: the whole action of which is very impetuous, and comes near to a convulsion; whence it wonderfully weakens the habit, and greatly injures the whole nervous system, as the maladies arising from thence seem to indicate, in consequence of the affection of the nerves, without which the semen cannot be expelled.

§ 5. *The Parts of Generation in Females.*

THE parts of generation in females are several in number, some of them external and some internal; and they are all subordinate to one principal internal part, called the *uterus*. The other internal parts are the *tubæ Fallopiæ*, *ovaria*, *vasa spermatica*, *ligamenta lata*, the ropes or bands called *ligamenta rotunda*, and the canal of the uterus. The external parts are the pubes, the *alæ nymphæ*, clitoris, orifice of the urethra, and orifice of the vagina.

Uterus. The uterus lies between the bladder and the *intestinum rectum*. It is a body inwardly hollow, outwardly of a whitish colour, of a pretty solid substance, and, except in time of pregnancy, of the figure of a
bat

flat flask, being in adults about three fingers breadth in length, one in thickness, and two in breadth at one end, and scarcely one at the other. This size varies, according to the age of the subject.

The broadest portion is termed the *fundus*, and the narrowest the *neck*. Its situation is oblique, the fundus being turned backward and upward, and the neck forward and downward; the broad sides lie next the rectum and bladder, and the narrow sides are lateral.

The cavity of the uterus is flat; and resembles an oblong triangle, the shortest side of which answers exactly to the fundus; and the two longest sides lie one on the right hand, the other on the left; and they are all bent inward, or toward the cavity formed by them.

Of the three angles of this cavity, the two which terminate the fundus are perforated each by a narrow duct, which with difficulty admits a hog's bristle. The third angle forms a flat duct wider than the former, which perforates the neck of the uterus lengthwise, and terminates at the extremity of that neck, by a transverse opening.

This opening is termed *the internal orifice of the uterus*; and in the natural state is narrower than the duct of the colum uteri, so that only a small stilet can be passed through it. At the edge of this orifice are several small holes, answering to the same number of glandular corpuscles, which discharge a viscid lymph.

The inner surface of the cavity of the uterus, is lined by a very fine membrane, which at the fundus or broad portion is smooth and even, but in the narrow portion which leads to the orifice, it is wrinkled in a particular manner.

The portion of this membrane, which covers the bottom of the cavity, is perforated by a great number of considerable holes, through which small drops of blood may be observed to pass, when the whole uterus is compressed; and sometimes it appears to have very small

hairs or villi. Both these villi and holes are observed to be more or less tinged with blood, in those women who die in the time of their menses.

In the narrow part, which answers to the colum, each side is divided into two lateral parts by a kind of prominent longitudinal line, which is larger in the upper or anterior side, than in the lower or posterior.

On each side of these two longitudinal lines, there are lines or rugæ obliquely transverse, and disposed like branches, the longitudinal lines representing trunks. Between and round these rugæ, there are small lacunæ, through which a mucilaginous fluid is discharged that closes the orifice of the uterus. We sometimes observe in the interstices between the rugæ, several transparent globular corpuscles, which vary much in size. Their nature is not yet well understood: they appear to be filled with a mucous lymph. Naboth considered them as ova.

Structure of the uterus. The substance of the body of the uterus is spongy and compact, with a copious intertexture of vessels. Its thickness is nearly equal and uniform in the sides and edges; but the fundus is thicker toward the middle than toward the two angles, where the thickness decreases gradually. The edges are likewise much thinner near these angles, than near the extremity of the neck.

The uterus is covered by a portion of the peritonæum, which serves it for a coat, and is the continuation of that which covers the bladder and intestinum rectum, running up from the lower and posterior part of the bladder, over the anterior part of the uterus, and from thence over the fundus, and down the backside, and afterwards going to the rectum.

On each lateral part or edge of the uterus this portion of the peritonæum forms a broad duplicature, which is extended on each side, more or less directly to the neighbouring lateral parts of the pelvis, forming a kind

kind of membranous septum, between the anterior and posterior halves of the cavity of the pelvis; and it is afterwards continued in a loose manner, with the peritonæum, on the sides of the pelvis.

Broad ligaments of the uterus. These two broad duplicatures have the name of *ligamenta lata*, and *vesper-tilionum alæ*. The upper edge of each is partly double, or folded, forming two small distinct duplicatures, which may be termed the *pinions of the broad ligaments*. The anterior pinion is more raised than the posterior, and they are both very loose.

The laminæ of all these duplicatures are connected by a cellular substance, in the same manner as the other duplicatures of the peritonæum; and they contain the Fallopian tubes, the ovaria, a part of the spermatic vessels, and of those that go to the body of the uterus; the ropes called the *round ligaments*, the nerves, &c.

Ovaria. The ovaria are two whitish oval, flat, oblong bodies, situated on the sides of the fundus uteri, to which they are fixed by a kind of short round ligament, and inclosed, together with it, in the duplicature of the posterior pinion of the *ligamenta lata*.

They are composed of a compact spongy substance, and of several little balls, or transparent vesiculæ, which are called *ova*; the number of which, according to Dr Haller, is found to be fifteen and upwards; tho' Sabatier says they are about ten or twelve, sometimes more, sometimes less; and that the liquor contained in them has all the qualities of lymph. The spongy substance surrounds each of these vesiculæ very closely, and seems likewise to furnish them with distinct spongy coverings or calices. These vesiculæ are to be carefully distinguished from other preternatural ones, termed *hydatides*.

The ligaments of the ovaria lie in the edges of the posterior pinions of the *ligamenta lata*, much in the same manner as the umbilical vein, in the anterior or

umbilical ligament of the liver. They are round ropes of a filamentary texture, fixed by one extremity to the corner of the fundus uteri, a little above and behind the level of that fundus. They were formerly believed to be hollow, and looked upon as vasa deferentia.

Tubæ Fallopianæ. The Fallopian tubes are two flaccid, conical, and vermiform canals, situated more or less transversely on each side of the uterus, between the fundus and the lateral parts of the pelvis, and included in the anterior duplicatures or pinions of the ligamenta lata.

Each of them is fixed by its narrow extremities in the corner of the fundus uteri, into which it opens, tho' by so narrow a duct, as hardly to admit a large bristle. From thence their diameter augments by degrees all the way to the other extremity, where it is about one-third part of an inch. The body of the tubæ goes in a winding course, and their large extremity is bent toward the ovaria.

These large extremities are irregularly round, and terminate by a narrow orifice, a little plaited and turned toward the ovarium, where it presently expands in form of a membranous fringe, full of plaits and incisures. These fringes are called the *broad ends of the Fallopian tubes*.

The breadth of the fringe is not equal in all parts. Its circumference is in a manner oval, and the longest segment of the fringe reaches to, and is fixed in the ovarium. The folds are disposed like laminæ on the concave side.

These tubes are composed of fleshy fibres, whereof some are longitudinal, and some obliquely circular, with an intertexture of another very fine substance.

The anterior pinions of the ligamentum latum serve for a common or external coat to both tubæ, and also to connect them, in the same manner as the mesentery connects the intestines. From thence the tubæ, and especially

especially their fringes, come to be loose, and their direction to be very imperfectly determined in the greatest part of the figures.

Their cavity is lined by a soft glandular membrane, which is plaited longitudinally, almost like the inner surface of the *aspera arteria*; and these folds are stronger and broader near the great extremities, than any where else. Their substance seems to be spongy, and the interstices between them are moistened more or less by a fluid, which is continually discharged there.

Blood-vessels. The blood-vessels of these parts are of different kinds, viz. the hypogastric arteries and veins, the ramifications of which belong chiefly to the body of the uterus; the spermatic vessels, and the two vascular ropes, called *ligamenta rotunda*, which might be more properly termed the *vascular ropes of the uterus* or of the *ligamenta lata*.

The hypogastric branches are arterial and venal ramifications, arising from the artery and vein of the same name; which having reached the lateral edges of the uterus, are distributed to all the parts thereof, both internal and external, forming a great number of incurvations and particular intertextures.

The arteries of one side communicate both upon the uterus, and through its whole substance, with those of the other side, and the arterial ramifications of each side form numerous anastomoses with each other. The veins communicate together on each side in the same manner; and all these blood-vessels communicate likewise with the spermatic vessels, with the vascular ropes of the *ligamenta lata*, and with the hæmorrhoidals.

These frequent anastomoses may be demonstrated by injecting or blowing into the hypogastric vessels, having first made proper ligatures to prevent the liquor or air from running into other parts. The extremities of these arteries terminate and open into the cavity of the uterus, as has been already said; and there is this pe-

culiar to the veins, that they communicate with the hæmorrhoidales, and consequently with the vena portæ.

The spermatic vessels have nearly the same origin in females as in males, and likewise the same course and intertextures; but they never pass out of the abdomen, being wholly distributed to the ovaria and tubes; and they communicate with the uterine hypogastrics, and with the vascular ropes of the ligamenta lata. The veins are very large in proportion to the arteries; and these vessels send out lateral ramifications, which seem to communicate with the meseraicæ and vena portæ.

The vascular ropes, commonly called the *round ligaments*, are two long small fasciculi of arteries, veins, and ligamentous fibres, interwoven and connected together by a fine cellular substance; and they run in the great duplicature of the ligamenta lata, from each corner of the fundus uteri, as far as the annular openings of the abdominal muscles.

In this course, each rope thrusts outward or raises the anterior lamina of the duplicature, which consequently gives a kind of coat to these vascular fasciculi, and makes them appear like distinct ropes connected to this foreside of the duplicatures.

They seem to arise from the communication between the vasa spermatica and hypogastrica, and might be reckoned a particular continuation of the spermatic vessels. The disposition of their adhesions to the angles of the fundus uteri, with respect to that of the tubes and ligaments of the ovaria, which lie all near each other, is this: The tubes lie highest, the ligaments of the ovaria most backward, and the vascular ropes forward, and a little lower than the ligaments of the ovaria.

Afterwards they run in a course, nearly resembling that of the spermatic vessels in males, pass out of the abdomen, through the openings of the abdominal muscles, and are lost in the fat of the upper and middle parts of the groins. As they pass out of the abdomen,

men, they are accompanied by a production of the cellular portion of the peritonæum, as the spermatic rope in men, and by a fasciculus of fleshy fibres, representing a kind of cremaster.

Nerves, lymphatics, &c. Besides all the vessels hitherto mentioned, we observe nerves and lymphatics, to which we may add the lactiferous ducts that are seen in an advanced pregnancy. The nerves come from the lumbares, sacri, and sympathetici maximi, in the same manner as in males. The lymphatic vessels run chiefly in the coats continued from the peritonæum.

Pubis. The pubis is that broad eminence at the lower part of the hypogastrium, between the two inguina, on which the hairs grow at a certain age, called in Latin by the same name, and almost of the same kind with those found under the axillæ. This eminence is owing to a particular thickness of the membrana adiposa which covers the fore part of the ossa pubis, and some small portions of the neighbouring muscles.

Sinus and alæ. The longitudinal cavity which reaches from the middle and lower part of the pubes, within an inch of the anus, was by the ancients termed *sinus*; and they called the lateral parts of the cavity *alæ*, which is a more proper name than that of *labia*, commonly given to them. The places where the alæ are joined above and below, are termed *commissures*; and may likewise be called *the extremities or angles of the sinus*.

The alæ are more prominent, and thicker above than below, and lie nearer each other below than above. They are chiefly composed of the skin, cellular substance, and fat. The exterior skin is a continuation of that of the pubes and inguina. It is more or less even, and furnished with a great number of glandular corpuscles, from which a whitish ceruminous matter may be expressed; and after a certain age it is likewise covered in the same manner with the pubes.

The inner side of the alæ is something like the red portion of the lips of the mouth; and it is distinguished every

every where from the external side by a kind of line, in the same manner as the red portion of the lips from the rest of the skin; being likewise thinner and smoother than the outward skin. A great number of pores are observable in it, and also numerous glandular corpuscles, which furnish a liquor more or less sebaceous; and these corpuscles are larger near the edges than in the other parts.

Lacunæ. Near the inner edge of the inner surfaces of the alæ, on each side of the orifice of the vagina, we find a small hole more visible than the rest. These two holes are termed *lacunæ*; and they communicate by two small ducts with the same number of follicular bodies lying in the substance of the alæ, and which may be looked upon as small prostates answering to the glandulæ prostaticæ inferiores in males. When compressed, they discharge a viscid liquor.

Above the superior commissure, a thin flat ligament runs down from each small branch of the ossa pubis, which penetrates the fat in the substance of each ala, and is lost therein insensibly near the edge. These may be looked upon as the ligamenta suspensoria of the alæ. The inferior commissure of the alæ is very thin, or like a membranous ligament; and, together with the neighbouring parts of the inner side, it forms a fossula, termed *navicularis*, or *scaphoides*. The space between the inferior commissure and anus, termed *perinaeum*, is about a large finger's breadth in length.

The other external parts are situated in the sinus, and hid by the alæ. Directly under the superior commissure, lies the clitoris, with its cover, called *præputium*. A little lower is the orifice of the urethra; and below that is the orifice of the great canal of the uterus. The circumference of this orifice is bordered, either by a membranous circle, called *hymen*, or by fleshy portions, termed *carunculæ myrtiformes*. On each side of the clitoris begins a very prominent fold, like a crista, which runs down obliquely on each side of the orifice

orifice of the urethra. These folds are termed *nymphæ*, and they might likewise be named *crista clitoridis*. On each side of the great orifice lies the small prostatic hole already described.

Clitoris. The clitoris appears at first sight like a small imperforated glans. Its upper and lateral sides are covered by a kind of præputium, formed by a particular fold of a portion of the inner side of the alæ; which appears to be glandular, and to discharge a certain moisture; and its inside is granulated.

By dissection, we discover in the clitoris a trunk and two branches, as in the penis, made up of a spongy substance, and of very elastic coats, but without any urethra. This substance may be inflated either by air or anatomical injections into the artery, &c. The trunk is divided into two lateral parts by a middle septum, from the bifurcation to the glans, where it is insensibly lost.

The bifurcation of the trunk is on the edge of the cartilaginous arch of the ossa pubis; and the branches, which resemble the roots of the corpora cavernosa, are inserted in the inferior rami of these bones, and in those of the ossa ischium, where they terminate by degrees; but there is sometimes a membranous tube on each side, which reaches to the tuberosity of the ischium.

The trunk of the clitoris is sustained by a ligamentum suspensorium fixed in the symphysis of the ossa pubis, and containing this trunk in its duplicature, nearly as in the other sex.

Four muscles or fasciculi of fleshy fibres are inserted in the trunk of the clitoris, two on each side. One of them runs down on the foreside of the neighbouring corpus cavernosum, and is inserted by a tendinous or aponeurotic portion, partly in the extremity of the corpus cavernosum, and partly in the tuberosity of the ischium. These two muscles are called *erectores*; but the name of *ischio-cavernosi* would be more proper.

The other muscle on each side lies under the former,
and

and runs down on the side of the urethra and great orifice of the uterus all the way to the anus; increasing gradually in breadth in its passage, and terminating partly like that which is called *accelerator* in males.

These two muscles surround very closely the lateral parts of the urethra and of the great orifice. They expand very much as they descend, and are spread on the lower and lateral parts of the great orifice; for which reason several anatomists have looked upon them as muscular sphincters. All these four muscles, and especially the two latter, are oftentimes almost covered with fat.

The blood-vessels of the clitoris come chiefly from the hypogastricæ, and the nerves from the second and third pairs of the nervi sacri; by means of which they communicate with the inferior mesenteric plexus, and with the great sympathetici.

Nymphæ. The nymphæ, cristæ clitoridis, or, as they may likewise be termed, *alæ minores sive internæ*, are two prominent folds of the inner skin of the great or external alæ, reaching from the præputium of the clitoris to the two sides of the great orifice of the uterus. They begin very narrow; and having increased in breadth in their course downward, they are again contracted at their lower extremity.

They are of a spongy substance, intermixed with glands; several of which may be perceived by the naked eye. Their situation is oblique, their upper extremities lying near each other, and the lower at a much greater distance. In married women they are more or less flaccid and decayed.

Urethra. By the urethra in females, we mean the urinary duct; the orifice of which is between the nymphæ below the glans of the clitoris. The sides of this orifice are a little prominent and wrinkled, and perforated by small lacunæ, from which a viscid or mucilaginous liquor may be squeezed. In time of pregnancy, this orifice is sometimes drawn a little inward.

The

The body of the urethra is a spongy duct of the same structure as in males, but much shorter, situated directly under the trunk of the clitoris, and above the great canal of the uterus, adhering to each of these canals between which it lies by membranous filaments. It passes under the cartilaginous arch of the ossa pubis, and terminates by an oblique opening at the neck of the bladder, being bent a little downwards between its two extremities.

The internal membrane of the urethra is a little plaited, and perforated by small holes, which communicate with folliculi, lying hid in its substance, as in males. If we blow into one of these holes, we observe a small canal to be inflated, which runs from without inwards, and terminates in some places by a kind of sacculus, by compressing which a viscid liquor is discharged.

The continuation of this membrane, which lines the neck of the bladder, forms likewise several rugæ, more or less equal; but that which lines the cavity of the bladder is wrinkled in an irregular manner when the bladder is empty.

The vagina. The great canal, formerly called the neck of the uterus, is situated below the urethra, and above the extremity of the intestinum rectum, a little obliquely, being more raised on the inner and back part than on the outer and fore part.

Its inner or posterior extremity joins the extremity of the body of the uterus, and surrounds its orifice much in the same manner as the duodenum surrounds the pylorus, or as the ileum is surrounded by the cæcum and colon.

The anterior extremity forms the great orifice, which lies under that of the urethra, and above the fossula of the inferior commissure of the alæ.

The body of the canal is chiefly made up of a spongy substance, interwoven with numerous blood-vessels; and it is commonly longer and narrower in virgins than in married women.

Its inner or concave surface has several transverse rugæ, and is covered by a particular membrane. The rugæ are formed by oblong narrow eminences, incurvated like portions of arches, placed very near each other, and disposed in such a manner as to divide the cavity of the canal into an upper and lower side.

By the union of the extremities of the upper and lower rugæ, a kind of raphe or suture is formed on the right and left sides; and both arches are sometimes intersected in the middle, and so form two half arches; but in this there is some variety.

In general, these arches are very considerable in young persons; become gradually more superficial in married women, and are quite lost in time of delivery.

The inner or posterior extremity of this great canal surrounds the orifice of the uterus a little obliquely, in such a manner as that the upper side of the canal lies very near the orifice, and the lower side at a greater distance from it; and this makes the extremity of the uterus appear to advance more into the canal on the lower than on the upper part.

Circulus membranofus. The exterior or anterior extremity of the great canal in virgins, and especially before the first eruption of the menles, is commonly bordered by circular membranous folds of different breadths, more or less smooth, and sometimes semilunar; which in some subjects leaves but a very small opening, in others a larger opening; and in all renders the external orifice narrower than the rest of the cavity. This fold, called *hymen*, is formed by the union of the internal membrane of the great canal with that on the inside of the alæ, and represents a membranous circle of different breadths, and sometimes uneven.

Carunculæ. This membranous circle is commonly ruptured after the consummation of marriage; is quite lost in delivery, and afterwards only some irregular portions of it remain; which, from their supposed resemblance to myrtle-leaves, have been termed *carunculæ myrtiformes*. This circle may likewise suffer some dis-

order by too great a flux of the menses, by imprudence, levity, and other particular accidents.

Plexus retiformis. Each side of the anterior portion of the great canal is covered exteriorly by a thin, broad, cavernous, and vascular plexus, called the *plexus retiformis* of that canal. These two planes run down on each side of the clitoris behind the nymphæ, and likewise cover the urethra like a collar, before they are spread on the great canal.

This plexus is strictly united to the muscular portions, commonly taken for accelerators or constrictors, lying between these portions and the lateral parts of the urethra and of the great canal.

This plexus may be inflated by air like a flaccid spleen, or like the spongy substance of the clitoris, with which it seems to have some communication; and on this account the lateral portions of this reticular plexus have been named the *internal crura* of the clitoris. It is a kind of rete-mirabile, composed of vessels which come chiefly from the hypogastricæ.

It still remains to be observed, that on each side of the bottom of the pelvis, in both sexes, opposite to the lower part of the bladder, there is an aponeurotic or tendinous ligament, which runs over the inner surface of the musculus obturator internus from before backward. The anterior extremity of this ligament is fixed on one side of the middle portion of the symphysis of the ossa pubis, and the posterior extremity to the middle part of the ligamentum sacro-sciaticum, formerly described.

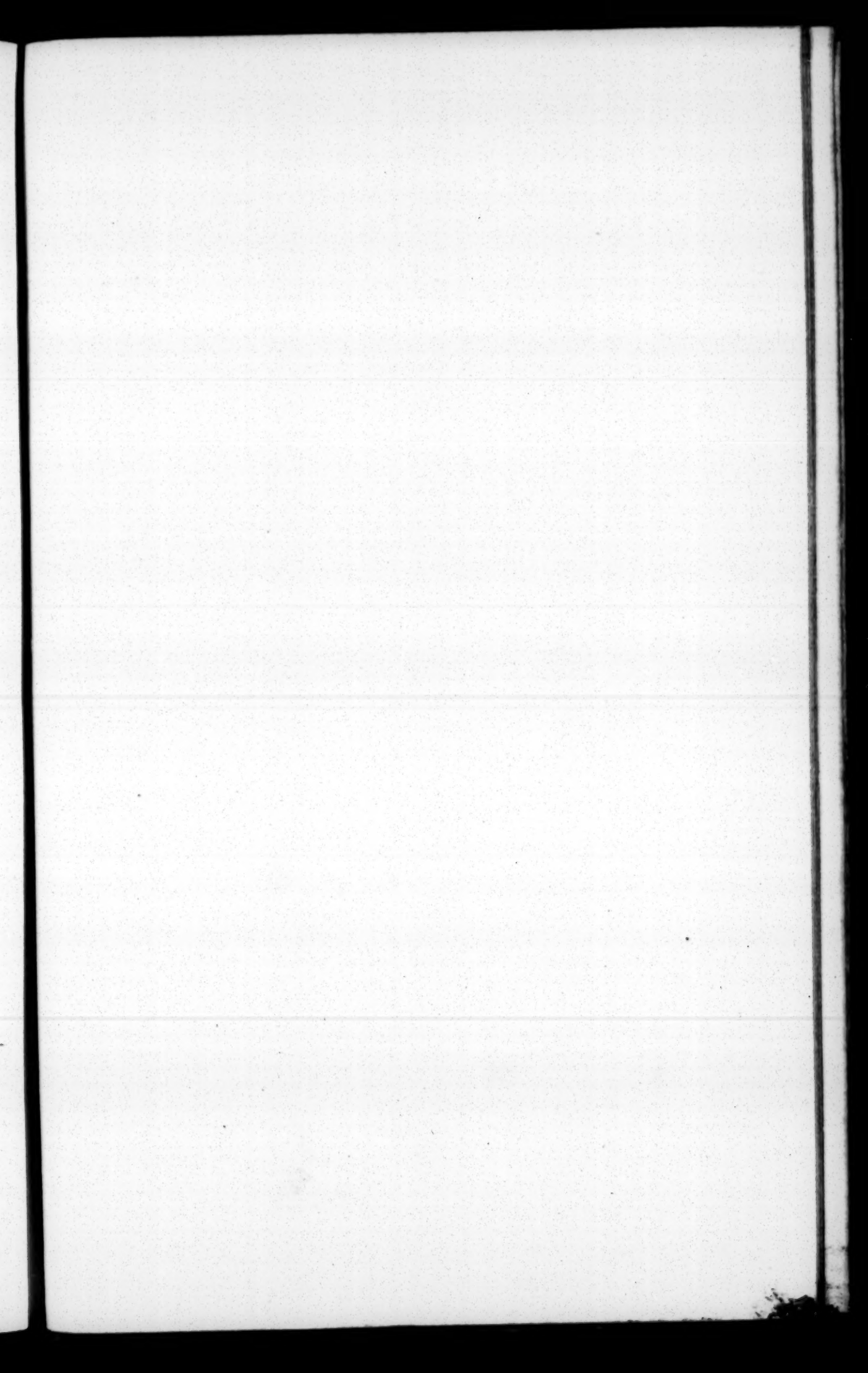
A little above the elongation called the *neck* of the bladder, there is another ligamentary expansion on each side of the bladder; the fore part of which is narrow, and fixed to the anterior extremity of the ligament already mentioned; and the broad posterior part to the side of the bladder. These two lateral expansions may be looked upon as proper ligaments of the bladder, by which it is connected to the inner side of both ossa pubis.

EXPLANATION of TAB. IX.

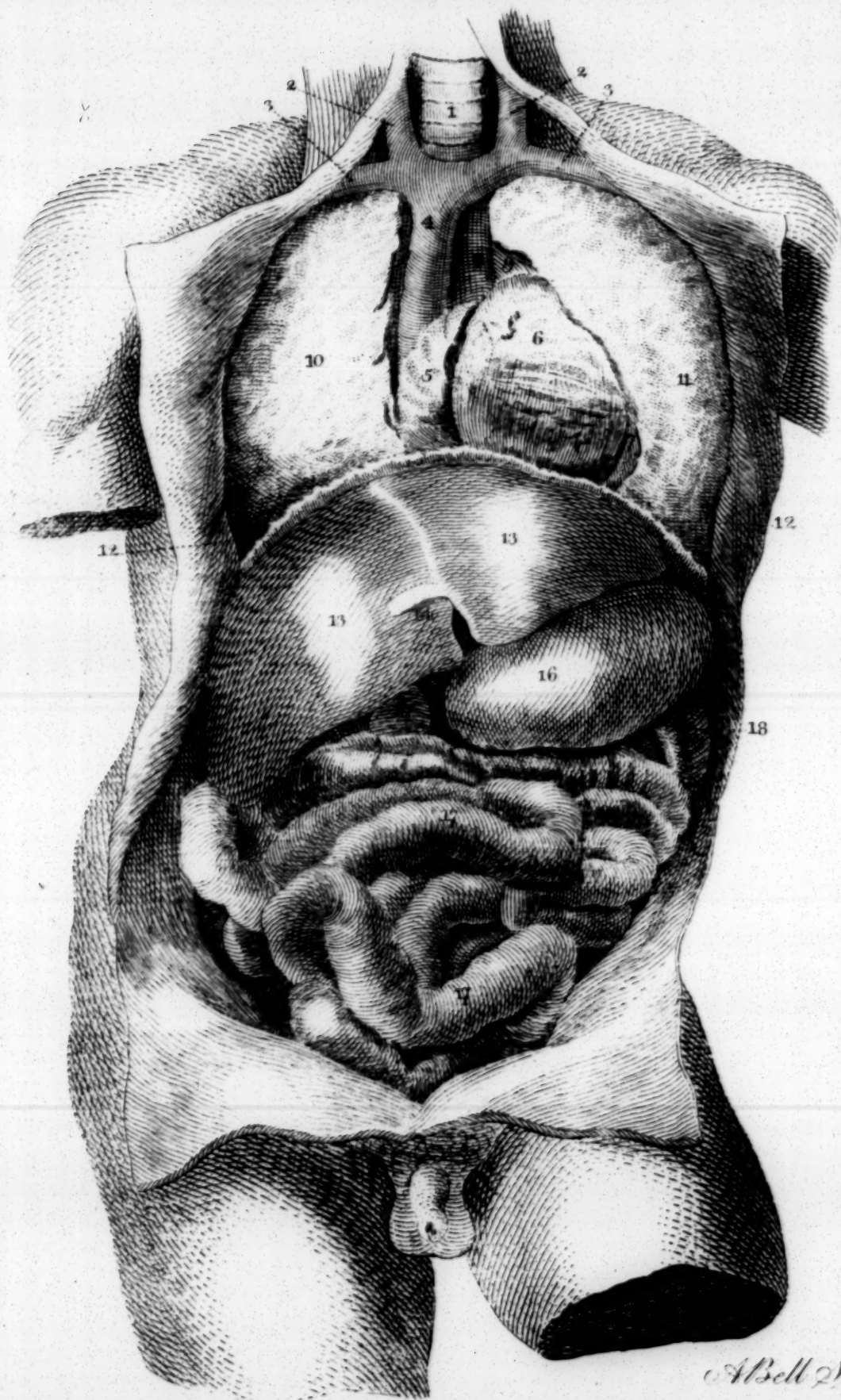
1. Trachea.
2. The internal jugular vein.
3. The subclavian vein.
4. Vena cava descendens.
5. The right auricle of the heart.
6. The right ventricle, the pericardium being removed.
7. Part of the left ventricle.
8. Aorta ascendens.
9. Arteria pulmonalis.
10. The right lobe of the lungs, part of which is cut off to show the great blood-vessels.
11. The left lobe of the lungs.
12. The diaphragm.
13. The liver.
14. The ligamentum rotundum.
15. The bottom of the gall-bladder projecting beyond the anterior edge of the great lobe of the liver.
16. The stomach, pressed by the liver toward the left side.
17. The small guts.
18. The spleen.

EXPLANATION of TAB. X.

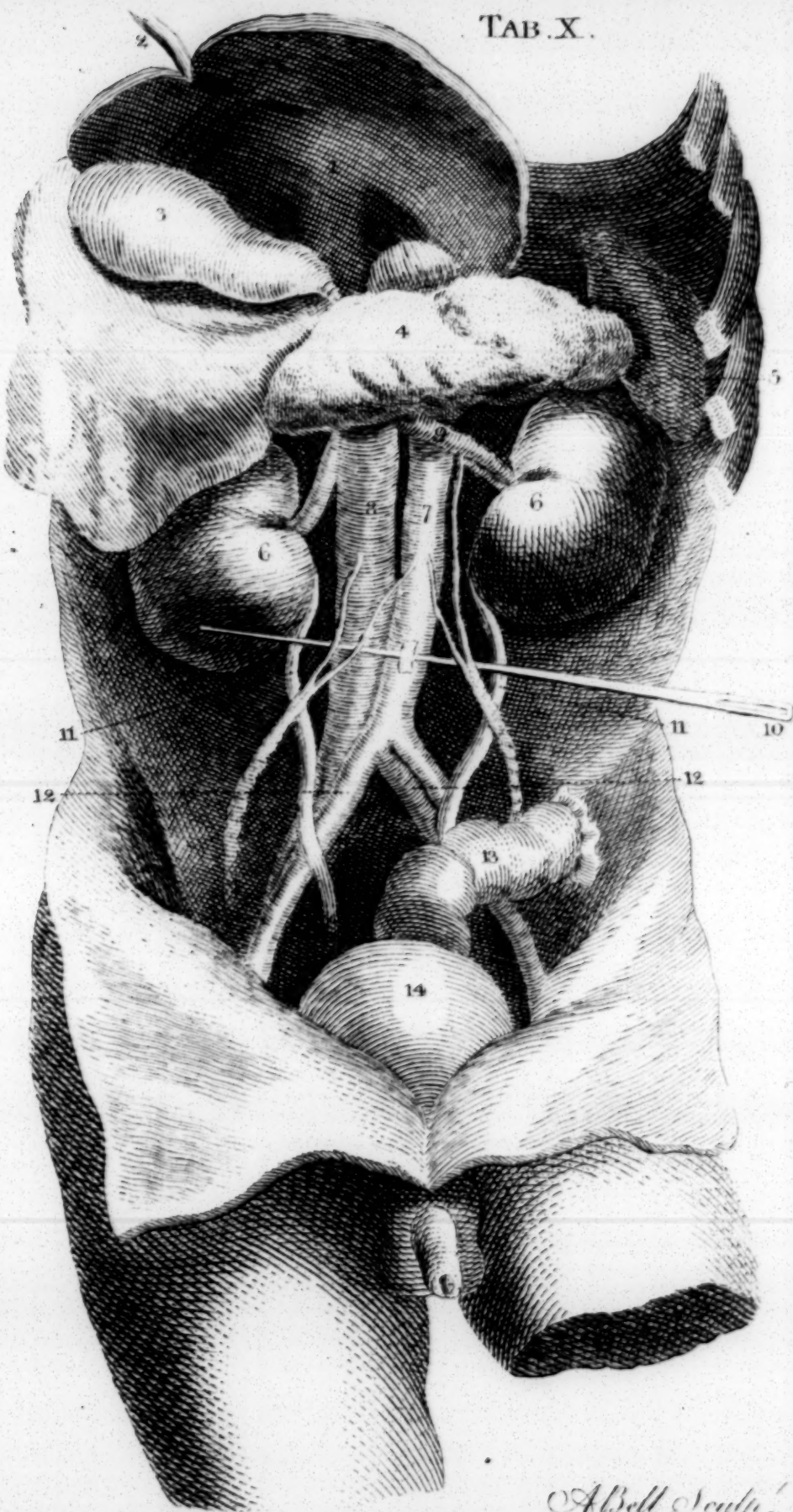
1. The under side of the liver.
2. Ligamentum rotundum.
3. The gall-bladder.
4. The pancreas.
5. The spleen.
6. The kidney.
7. Aorta descendens.
8. Vena cava ascendens.
9. The emulgent vein.
10. A probe under the spermatic vessels and the arteria mesenterica inferior, and over the ureters.
11. The ureter.
12. The iliac vessels.
13. The rectum intestinum.
14. The bladder of urine.



TAB. IX.



TAB. X.



A. Bell Sculp.

I N D E X

TO VOLUME SECOND.

A.
ABDOMEN described, 306. Integuments of it, 307. Its cavity, 308.

Alæ minores, five internæ, a name of the nymphæ, 465, 468.

Antiprostatæ described, 444.

Anus, 336.

Aorta, receives the blood from the left ventricle of the heart, 219.

— descendens, 219.

Appendices epiploicæ, 393.

Appendicula vermiformis, 331.

Aqueducts of Cotunnus, 150.

Arbor vitæ, 34.

Areola of the breasts described, 206.

Arteria pulmonaris, 219.

— spinæ, 34.

— coronariæ, 221.

— hepaticæ propriæ, 372.

— umbilicales, 420.

Auriculæ of the heart, 219. Appendix of the left, 221.

B.

Basilic vein, 451, 458.

Bile, account of it, 394. Secretion, *ib.*

Bladder, its situation, figure, and division, 410. Its structure, *ib.* Its blood-vessels and nerves, 428.

Blood and juices, their nature, 244. Its heat, *ib.* The vapour, exhalation from it, 245. Crassamentum, *ib.*

Pleuritic crusts, how formed, 246.

Sea-salt in the blood, 247. Earth, *ib.* Iron, *ib.* Air, *ib.* Experiments

with different substances, *ib.* The blood analysed, 248. Viewed with a microscope, 249. Diameter of its

globules, 250. Fibres, *ib.* Serum, *ib.* Cause of its redness considered,

297.

Blood-vessels: two different kinds of them in the lungs, 237.

Brain and its appendages described, 10.

Bronchiæ described, 268.

C.

Calamus scriptorius, 33.

Capsula Glissoni, 370.

Capsulæ atrabiliaræ, 414.

— renales, *ib.*

Cartilagine crico-thyroideæ, 175.

— crico-arytenoidæ posteriores, *ib.*

— crico-arytenoidæ laterales, *ib.*

Cartilago thyroidea, 174.

— cricoides, 175.

Caruncula lachrymalis, 96. Of the urethra, 441.

Carunculæ myrtiformes, 470. Why so called, *ib.* Described, *ib.*

Centrum ovale of the brain, 25.

Cerebellum described, 32.

Cerebrum described, 22.

Cheeks described, 160. Muscles of them, 262.

Chrystalline lens, its density and refracting power, 109.

Cilia described, 95.

Circulation of the blood, 125, 260.

Circulus membranofus described, 470.

Clitoris described, 467. Its trunk and muscles, *ib.* Origin of its blood-vessels, 468.

Cochlea of the ear, 143.

Cæcum: a division of the intestines so called, 331. Its nerves, 345.

Colon: an intestine, 332. Nerves of its arch, 345. Of its last convolutions, *ib.*

Concave glasses, their use, 113.

Cor, 214.

Corpora albicantia, 45.

— fimbriata,

— cavernosa, 442.

— pyramidalia, 36.

— striata, their description and situation, 28.

Corpus callosum, 42.

Coughing, 299.

Cremaster muscle, its description, origin, and use, 430.

Crista clitoridis, 467.

D.

Dartos muscle described, 428.

Deglutition, 193.

Diastrale, what, 225.

Digestion, how performed, 346.

Distance considered, 126.

Duct, thoracic. Its difference of size

in different subjects, 305.

Ductus auris palatinus, 145.

— choledochus, 373.

— cysticus, *ib.*

— cycto-hepatici, 375.

— hepaticus, 371.

— incisorii, 125.

— lachrymalis, 124.

H h

Ductus

- Ductus lactiferi**, 205.
 — **pancreaticus**, 385.
 — **thoracicus**, 305.
 — **Virfungi**, 385.
Duodenum, a division of the intestine so called, 324. Structure, 325. Glands, 326. Arteries and veins, 342. Nerves, 345.
Dura mater, its situation, division, composition, &c. 11.
 E.
Ear, 130. Muscles, 133. Arteries, 135. The bony parts of it, 136. Internal soft parts, 163.
Epididymis described, 431.
Epiglottis, its figure, 178.
Eye, 75. Its situation and composition, *ib.* The orbits, *ib.* Humours and capsulæ, 77. Muscles of the globe, 86. Their number, names, situation, and use, 87. Nerves, 99. Vessels and appendages, 98.
 F.
Fenestra ovalis, 138.
Foramen lacerum, 20.
Fornix, description of it, 26.
 G.
Generation; male parts of, 427.
 — female, 458.
Glandula pinealis, 32.
 — **pituitaria**, 30.
 — **lachrymalis**, 93.
Glandulæ amygdalæ, 179, 192.
 arytenoidæ, 176.
 bronchiales, 276.
 buccales, 189.
 ceruminosæ, 135.
 ciliares, 95.
 conglobatæ, 186.
 labiales, 189.
 linguales, *ib.*
 maxillares, 189.
 molares, *ib.*
 Pacchioni, 58.
 palatinæ, *ib.*
 parotides, 189.
 renales, 414.
 salivales, 189.
 sublinguales, 189.
Glans penis described, 440.
Globe or ball of the eye; 77. Its composition, coats, humours, &c. *ib.*
Glottis, 177.
Gums described, 160.
 H.
Head, 9.
Hearing, 152. Produced by the vibrations of the air, 153.
Heart, particular situation of it, 214. Uses, fleshy fibres, substance, &c. 224. Its physiology, 226.
Heart, innate motion, 230.
Hepar, 365.
Hiccup, 300.
Humours of the eye, 83.
Hymen, a membranous circle so called, 466.
 I.
Jejunum, a division of the intestines so called, 327. Its situation and size, *ib.* Its structure, *ib.* Its arteries, 342. Nerves, 345.
Ileum, an intestine so called, 329. Its situation and structure, *ib.* Its blood-vessels, &c. 342.
Incus of the ear described, 138.
Infundibulum, 30.
Intestines, 321. Their situation, size, and division, *ib.* Their structure, 321. Their blood-vessels, 342.
Intestinum cæcum, its situation and structure, 331.
 — **colon**; its situation, &c. 275. Its cells, *ib.*
 — **duodenum**, 324.
 — **ileum**, 329.
 — **rectum**, 336.
Iris, 80.
Iter ad quantum ventriculum, 31.
 K.
Kidneys; their situation, figure, and division, 407. Their blood-vessels, *ib.* Coats, 408. Substance, 410.
Pelvis, 411.
 L.
Labyrinth of the ear, 141.
Lacunæ of the urethra, 444. Of the parts of generation in women, 466.
Larynx, 174. Its ligaments and muscles, 177. How divided, *ib.*
Laughter, 300.
Lien, 383. The human one very different from that of brutes, 385.
Ligamenta tarsorum lata, 92.
Ligamentum vesicæ suspensorium, 446.
 — **cilare**, 80.
 — **coronarium**, 368.
 — **hepatis suspensorium**, improperly so called, 368.
 — **intermaxillare** described, 203.
 — **pubis interosseum**, 281.
Light, how its rays are refracted, &c. 106.
Lips described, 160. Great variety in their muscles, 162. Enumeration of them, *ib.* Upper lip sometimes moved by the muscles of the nose, *ib.*
Lobes of the liver described, 366.
Lobulus Spigelii, the small lobe of the liver described, 367.
Liver, its external coats, 375. Remarks on its vessels, 378.
Lungs, their vessels, 267. Use, 277.
 — **general and particular situation**, figure

figure and division, 267. Lobes, 268. Structure, *ib.* Coats, *ib.* Interlobular substance, 269. Vessels, 270. Nerves, 272. Lymphatic vessels, *ib.* Ligaments, *ib.*

M.

Malleus of the ear described, 139.
Mammæ described, 204. Their body, *ib.* Corpus adiposum, 205. Arteries, veins, and nerves, 207. Uses, 208.

Mastication, 193.

Meatus externus described, 136. Wanting in children, *ib.*

— internus, 144.

Mediastinum described, 209.

— scroti, 428.

Medulla oblongata, 35. Its substance, *ib.* Productions, 36.

— spinalis described, 40. Substance and body, 41. Productions, 42.

Membrana arachnoidea, 42.

— conjunctiva described, 93.

— Ruyfchiana, 80.

— tympani, 165. Haller's opinion of its perforation, *ib.*

Mesentery described, 338. Its division, *ib.* Structure, 339.

Mesocolon, 338.

Motion, peristaltic, of the intestines, 320, 358.

Mouth, 159. Meaning of the word, *ib.* Its external and internal parts, *ib.* 160.

Myopes, why so called, 113.

N.

Nates cerebri, 28

Navicularis, the fossula so called, 446.

Nerves of the brain and spinal marrow, 43. Of the medulla oblongata, *ib.* First and second pair, *ib.* Third pair, 45. Fourth pair, *ib.* Fifth and sixth pairs, 46. Seventh, eighth, and ninth pairs, 47. Tenth pair, 48. Nerves of the medulla spinalis enumerated, 48, 49. Their productions, 50. Nerves of the nose, 126. Of the lungs, very numerous, 272. Of the stomach, 319. Of the intestines, 345. Of the liver, 372. Of the pancreas, 382. Of the spleen very numerous, 387. Of the kidneys, 408. Of the bladder, 422. Of the parts of generation in males, 449. Of the parts of generation in women, 465. Composition, 62. Size of their fibres not known, *ib.* Their substance very tender, *ib.* Different opinions concerning their solidity, 69. Supposition of an extreme rapidity in the motion of the

nervous fluid, 71. Various arguments for and against it, 72.

Nose, its external and internal parts described, 118. Of the nerves, 126.

Cartilages, 119. Muscles, 121. Uses of them, 121. Arteries, 126.

Nymphæ described, 468. Their substance, *ib.*

O.

Objects, whether or not painted on the retina, considered, 110.

Oesophagus, its situation, figure, &c. 303.

Omentum, 390. Its structure, 391. Vessels, 394.

— little, described, *ib.*

Os orbiculare, 141.

Officula auditus, 138.

Ova, 461.

Ovaria, 461. Their composition and ligaments, *ib.*

P.

Palate described, 163.

Palpebræ described, 91.

Pancreas described, 384. Its situation, division, and figure, *ib.*

Papilla of the breast, 206. Its body, texture, &c. *ib.*

Pedes hippocampi, 27.

Pedunculi cerebelli, 34.

Pericardium, 212.

Pericranium described, 9.

Peritonæum, 308. Cellular substance, 309. Its productions, *ib.* Round ligaments, *ib.*

Pharynx described, 187. Its muscles, 188.

Physiology of the brain and nerves, 55.

Pia mater described, 12.

Pleura described, 208. Its arteries and veins, 210. Nerves, *ib.* Use, *ib.*

Plexus choroidæ, 30.

— retiformis, 471.

Pomum adami, 174.

Pons varolii, 36.

Pori biliarii, 371.

Preputium in men, 445.

Presbyopi, what, and why so called, 114.

Prostatæ described, 439.

Pubes, 465.

Pudicæ, arteries so called, 357. Their origin, *ib.*

Pulmones, 267.

Puncta lachrymalia, 95.

Pylorus described, 313, 317.

R.

Rays, their divergency, refraction, and reflection, considered, 108.

Rectum, a division of the intestines so called, 336. Its arteries furnished by

- by the hæmorrhoidals interna, 342.
 Its veins ramifications of the mesaraica minor, *ib.* Its nerves, 345.
 Refraction, what, 107.
 Renes, 407.
 — succenturiati, *ib.*
 Respiration, 179. Wrißberg's account, 301. Drs Monro and Haller's opinions, 106.
 Retina, 81. From what produced, *ib.*
 S.
 Sacculus lachrymalis, 123.
 Saliva, 193.
 Scrotum described, 417.
 Sella turcica, 30.
 Semen, 450.
 Septum lucidum, 26.
 — palati, 164.
 Sight described, 102.
 Singing explained, 186.
 Sinus venosus sinister, 221.
 — vaginæ, 465.
 — venosi, 55.
 Smelling, 127.
 Sneezing, 300.
 Soul, its seat, 67.
 Sound explained mathematically, 154.
 Speech performed by means of the tongue, 186. Instances of people who spoke without one, 173.
 Spleen described, 383. Course of its lymphatic vessels, 386.
 Stapes, a bone of the ear, 140.
 Succus gastricus, or stomachicus, described, 317.
 — pancreaticus, 383.
 Stomach, figure, curvatures, &c. 313.
 Use, 320.
 Supercilia, 89.
 Systole, what, 224.
 T.
 Tarsi of the palpebræ described, 92.
 Taste, how occasioned, 171.
 Tears, how produced, 103.
 Temperaments considered, 251. Dr Wrißberg's account of them, 254.
 Testes described, 429. Their coats, *ib.*
 Testes cerebri, 28.
 Thalami nervorum optiçorum, 28.
 Thorax, 202. Its cavity, 203. Arteries and veins of it, 207.
 Thymus described, 211.
 Tongue described, 165. Papillæ of three different kinds, 166. Its muscles, 168. Ligaments and blood-vessels, 169. Nerves, 170. Its uses, 171. Instances of people who spoke without a tongue, 174.
 Torcular herophili, 20.
 Trachea arteria described, 173. Its several coats, 276.
 Tubæ Fallopiæ described, 462.
 Tuberculæ of the brain, 31. Different names given them by the ancients and moderns, *ib.*
 — quadrigemina, *ib.*
 Tubus Eustachianus, 137.
 Tunica vaginalis, &c. of the testicles, 429.
 — arachnoidæa, 22.
 — choroides, 79.
 — scleratica, 78.
 — cornea, *ib.*
 — albuginea, 86.
 Tympanum, 136.
 U. V.
 Vagina, &c. 469.
 Valvula palati described, 187.
 — coli, how formed, 333, 334.
 Valvulæ auriculares, 218.
 — semilunares vel sigmoidales, 214.
 — tricuspedes sive triglochines, 214, 218.
 — mitrales, *ib.*
 — conniventes, 325. Their formation, *ib.*
 Vasa deferentia, how formed, 436.
 — spermatica, 435.
 Velum pendulum palati, 164.
 Vena epiploica sinistra, 394.
 — epiploica dextra, *ib.*
 — portæ hepaticæ, 370.
 Venæ pulmonares, 221.
 — coronariæ, *ib.*
 — hepaticæ, 371.
 — pudicæ internæ, 447.
 Ventricle, third, of the brain, 29.
 — fourth, 33.
 Ventriculi laterales, 26.
 Ventriculus, 313. Its coats, 316.
 Vesica urinaria, 419.
 Vesicula fellea, 365, 374.
 Vesiculæ bronchiales, 269.
 — feminales, 432.
 Vestibulum auris, 141.
 Voice, 182. How produced by the air in respiration, 183. Acute and grave sounds accounted for, 184.
 Urachus described, 420.
 Ueters, 411.
 Urethra, 443. In women, 468.
 Urine, 423.
 Uterus, 458. Its canal, commonly called the neck, 459. Its situation and substance, 460.
 Uvea, 80.
 Uvula described, 163.
 W.
 Weeping, 300.

